

AD-A101 706

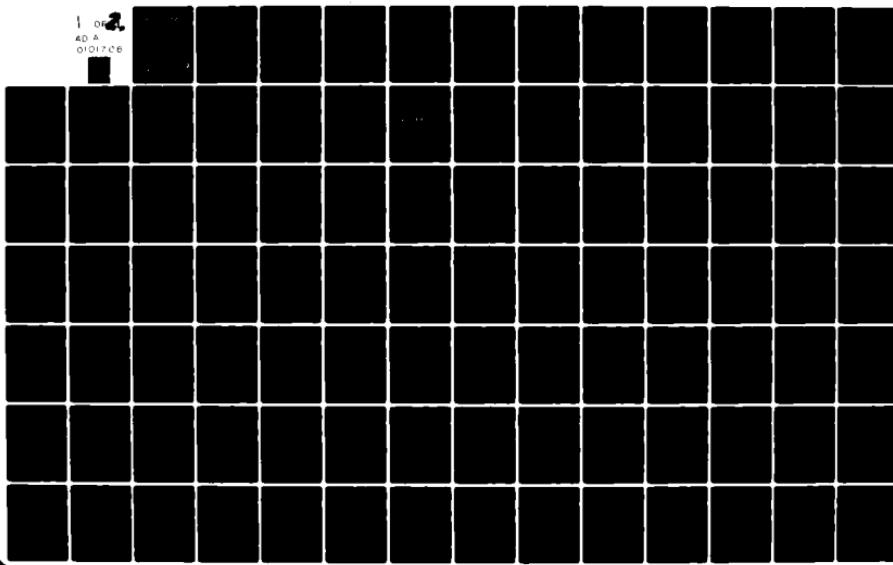
GENERAL ACCOUNTING OFFICE WASHINGTON DC PROGRAM ANAL--ETC F/6 5/1
CONSISTENT CRITERIA ARE NEEDED TO ASSESS SMALL-BUSINESS INNOVAT--ETC(U)

JUL 81

UNCLASSIFIED GAO/PAD-77-71

NL

1 of
40 A
0101706



AD A101706

BY THE COMPTROLLER GENERAL

Report To The Congress

OF THE UNITED STATES

Consistent Criteria Are Needed To Assess Small-Business Innovation Initiatives

In this report, GAO explains the activities of small businesses as innovators and presents models that show the influence of economy-wide, industry-specific, and individual-firm factors on the environment within which small businesses innovate. The conditions that support small businesses as innovators are spelled out, as are the conditions amenable to Federal policy manipulation.

To assist the Congress with its continuing concern about a perceived decline in U.S. industrial innovation, GAO suggests criteria for judging the efficacy of Federal initiatives to support small-business innovation. GAO demonstrates the usefulness of these criteria by examining the design of existing Federal programs.

GAO recommends that in its deliberations on initiatives currently under consideration and on future initiatives, the Congress use the criteria presented in this report to assess the degree to which the initiatives satisfy the conditions that foster innovation by small businesses.



DMC FILE COPY

This document has been approved
for public release and sale; its
distribution is unlimited.

JUL 21 1981
PAD-81-15
JUL 21 1981

81 7 20 144



COMPTROLLER GENERAL OF THE UNITED STATES
WASHINGTON D C 20548

B-201548

To the President of the Senate and the
Speaker of the House of Representatives

The Congress has become increasingly concerned about the perceived decline in U.S. industrial innovation. In this report, we provide a comprehensive picture of the innovative activities of one of the important sources of innovation in this country--small businesses.

We made this review because we recognized the importance of innovation to our national economy and acknowledged the important role of small business in innovation. We also realized, however, that until now there has been no comprehensive review of what is known about small businesses and innovation. In this report, we examine the conditions that influence the ability of small businesses to innovate and provide criteria for assessing the extent to which Federal initiatives are likely to foster innovation by small businesses.

We are sending copies of the report to appropriate House and Senate committees, Representatives and Senators who have particular interest in the subject, the Director of the Office of Management and Budget, the Administrator of the Small Business Administration, the Secretary of Commerce, the Director of the National Science Foundation, and the Director of the Office of Science and Technology Policy. We will also make copies available to interested organizations and individuals, as appropriate, on request.

Accession No.	
NTIS GRADE	
TYPE	
CLASSIFICATION	
DATE RECEIVED	

Milton J. Rosler
Acting Comptroller General
of the United States

A

D I G E S T

Today's concern about the ability of small businesses to innovate is prompted by a larger concern about a perceived decline in U.S. industrial innovation and the belief that small businesses are vital to innovation in this country. The small-business community has voiced concern that the ability of small businesses to be active in innovation is inhibited by a number of Federal policies. The Congress has responded actively with legislation that addresses both the question of declining industrial innovation and the issue of the ability of small businesses to be innovative.

In this report, GAO provides a comprehensive picture of small-business innovation by showing what influences the environment within which small manufacturing businesses innovate and how these small businesses act as innovators in that environment. The objective of this report is to answer three questions:

- What influences the environment within which small businesses innovate?
- How do small businesses act as innovators in that environment?
- How can our understanding of the answers to these two questions contribute to Federal policymaking efforts to support small businesses as innovators?

In addressing these questions, GAO focuses on innovation in small businesses in the manufacturing sector.

GAO did not examine the activities of university or government laboratories, large or medium-sized businesses, or other institutions engaged in innovative activities. GAO also did not determine whether small businesses are more important to innovation than other innovators or attempt to quantify the innovation deriving from small businesses. GAO did not examine whether small businesses are inhibited by specific Federal policies in their efforts to

innovate or whether the Federal Government should support small-business innovation in preference to supporting other potential innovators.

THE FACTORS THAT INFLUENCE SMALL-BUSINESS INNOVATION

The climate for innovation within a firm is a combination of the characteristics of that particular firm, including the capabilities and entrepreneurial nature of key individuals within it, the industry in which it operates, and the broader economy-wide climate affecting both the industry and the firm. (pp. 12-21) The activities of small businesses as innovators are largely determined by their industry structure and other industry-specific variables. Small businesses are most likely to be primary contributors in an industry or a sector of an industry in which most firms are small. They are likely to be complementary contributors in more concentrated industries, where they tend to perform specialized innovative functions and develop products or processes used by other, usually larger, firms in that industry. (pp. 24-27)

While a number of factors influence the climate within which small businesses innovate, only some can be manipulated by Government policy. Among economy-wide factors, only incentives and barriers are readily amenable to policy influence. Industry-specific factors that public policy can affect are the availability of resources, technological opportunity, and the balance between supply and demand. Within individual firms, the availability of resources and technological opportunity are most amenable to Government policy influence. (pp. 31-32)

CRITERIA FOR ASSESSING FEDERAL INITIATIVES TO SUPPORT SMALL-BUSINESS INNOVATION

Analyzing the factors that influence innovation allowed GAO to isolate the conditions that are necessary, the conditions that are important, and the conditions that are desirable if small-business innovation is to flourish. Based on these conditions, GAO developed criteria for judging the efficacy of Federal initiatives intended to foster small-business innovation. (pp. 32-33)

To satisfy the criteria for conditions necessary in fostering small-business innovation, Federal initiatives should

- encourage exploitation of technological opportunity,
- ensure managerial and technical capacity of individual firms,
- ensure adequacy of financial and human resources throughout the innovation process, and
- promote innovation in technologies or industries in which small businesses can assemble requisite resources.

To satisfy the criteria for conditions important in fostering small-business innovation, Federal initiatives should

- stimulate creation and augmentation of technological opportunity and
- increase availability of financial and human resources.

To satisfy the criteria for conditions desirable for fostering small-business innovation, Federal initiatives should

- address enough incentives and barriers to influence the balance between them positively.

GAO demonstrates the usefulness of these criteria by considering the design of several existing Federal efforts to support the activities of small businesses as innovators. Use of the criteria with Federal efforts to influence economy-wide factors (such as tax and patent policies) indicates that such efforts might be expected to affect the economy-wide climate for innovation positively. A positive economy-wide climate is desirable but does not meet the necessary criteria for conditions supporting small-business innovation. (pp. 35-36)

Use of the criteria with Federal programs designed to provide funding or technical and management assistance directly to small businesses (such as the National Science Foundation's Small Business Innovation Research

program) indicates that such programs would be likely to meet the necessary criteria for conditions supporting the activities of small businesses as innovators. (pp. 36-40)

CONCLUSIONS

Having analyzed the factors that influence the environment for innovation, the activities of small businesses within that environment, and the conditions that support small businesses as innovators, GAO concludes that small businesses act differently as innovators depending on the characteristics of the industry of which they are a part. How likely it is that small businesses will innovate is influenced by a complex set of economy-wide, industry-specific, and individual-firm factors. Only some of the factors that influence the environment for innovation are readily amenable to Federal policy influence. The environment for innovation is common for all potential innovators. Actions intended to affect one category of innovator will also affect others, although the effects may be quite different. (pp. 45-46)

Finally, GAO presents several specific questions for research that would usefully augment the information in this report. (pp. 46-47)

AGENCY COMMENTS

The National Science Foundation (NSF), the Small Business Administration (SBA), and the Department of Commerce (DOC) commented on a draft of this report, and all three agreed that the report makes an important contribution to what is known about small businesses and innovation. DOC stated that GAO's approach is "systematic, unbiased, and more comprehensive than existing studies." (p. 81)

NSF and SBA commented that the report should more specifically reflect the importance of the entrepreneurial role and the profit motive. While GAO agrees that these are important influences, GAO has taken them to be implicit elements of the conditions that are conducive to innovation and therefore does not discuss them explicitly. (pp. 47-49)

Also, SBA asked GAO to remove its reference to the SBA-funded innovation centers because they are experimental and have not yet been eval-

ated. GAO appreciates SBA's concern that neither positive nor negative comments be made about these centers until they have been evaluated. It was GAO's purpose not to evaluate these programs, however, but simply to illustrate the usefulness of the criteria GAO developed for judging the efficacy of Federal initiatives. This point is made explicitly where appropriate in the report, and the references remain. (p. 49)

DOC was concerned that models GAO presents in chapter 2 "raise more questions than they help to answer" and that GAO might have used case studies instead of models to view the complex relationships they depict. (p. 82) GAO agrees that case studies would amplify the models, but the models are presented as hypotheses, and questions are therefore to be expected.

RECOMMENDATION TO THE CONGRESS

The Congress has responded actively to the perceived decline in innovation in this country by making numerous efforts to stimulate innovation in general and to support the activities of small businesses in particular. GAO recommends that in its deliberations on bills currently pending and on future initiatives to support small-business innovation, the Congress use the criteria presented in this report to assess the degree to which proposed initiatives are likely to enhance the conditions that foster innovation by small businesses.

Contents

	<u>Page</u>	
DIGEST	i	
CHAPTER		
1	INTRODUCTION	1
	The concern that innovation is declining	1
	Objective, scope, and methodology	2
	Definition of innovation	7
	Organization of the report's topics	10
2	FACTORS THAT INFLUENCE THE ENVIRONMENT	
	FOR INNOVATION	12
	The environment for innovation	13
	Factors in the climate of the	
	economy	13
	Factors in the climate of the	
	industry	15
	Factors in the climate of the firm	19
	The environment as a determinant	
	of innovation	21
3	SMALL BUSINESSES AS PARTICIPANTS	
	IN INNOVATION	24
	The variation of small-business	
	activity from industry to industry	24
	The special case of new small businesses	
	and emerging industries	27
4	CONDITIONS THAT SUPPORT SMALL BUSINESSES	
	AS INNOVATORS	29
	Conditions that support innovation	29
	Conditions amenable to policy action	31
	Criteria for Federal initiatives	
	to improve conditions that support	
	innovation	32
	Federal activities to support small	
	businesses as innovators	33
	Efforts to influence economy-wide	
	factors	35
	Programs that provide funding	
	or management and technical	
	assistance	36

	<u>Page</u>	
CHAPTER		
5	SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS	41
	The environment for innovation for small businesses	41
	The innovative activities of small businesses vary by industry	42
	Conditions conducive to innovation	42
	Criteria for Federal initiatives to support small-business innovation	43
	Some Federal activity designs meet necessary criteria	44
	Conclusions	45
	Further important research	46
	Agency comments and our response	47
	Recommendation to the Congress	49
APPENDIX		
I	Annotated bibliography of studies of sources of invention and innovation	51
II	Measurement and methodological problems in the innovation literature	53
III	Selected bibliography	56
IV	Programs that provide funding for the innovation process	65
V	Programs that provide technical and management assistance	69
VI	Letter dated May 28, 1981, from the National Science Foundation and our response	74
VII	Letter dated June 4, 1981, from the Small Business Administration and our response	77
VIII	Letters dated June 3, 1981, from the Department of Commerce and our response	80

TABLE

		<u>Page</u>
1	The innovation process--activities and functions, personnel, resources, and results	9
2	The economy-wide factors that influence the climate for innovation	14
3	The industry-specific factors that influence the climate for innovation	17
4	The firm factors that influence the climate for innovation	20
5	Conditions necessary, important, and desirable to support innovative activities of small businesses	30
6	Demonstration of usefulness of the criteria with existing Federal activities	34
7	Examples of Federal programs that assist small innovative businesses	37

FIGURE

1	The stages of innovation	8
2	The three climates for innovation and their relation to the innovation process	12
3	The economy-wide model	13
4	The industry model	16
5	The firm model	19
6	The relationships between the economy-wide, industry, and firm models and the innovation process	22
7	The activities of small businesses in different industry structures	25

ABBREVIATIONS

AT	Appropriate Technology Small Grants Program
CCSC	Commercial Credit Services Corporation
CFI	Center for Innovation
DARPA	Defense Advanced Research Projects Agency
DOC	Department of Commerce
DOD	Department of Defense
DOE	Department of Energy
GAO	General Accounting Office
MERDI	Montana Energy and MHD Research and Development Institute
NSF	National Science Foundation
R&D	Research and development
SBA	Small Business Administration
SBIR	Small Business Innovation Research Program

CHAPTER 1

INTRODUCTION

THE CONCERN THAT INNOVATION IS DECLINING

As we move into the 1980s, attention is focused on a growing concern over whether the rate of U.S. industrial or technological innovation is declining. The perceived erosion of innovation is believed to undermine our Nation's security, its continued economic viability, and the quality of our lives. The small-business sector of the economy has come particularly into focus, because small businesses are believed to contribute more than their proportionate share of innovations to our economy. They are believed to be more flexible and responsive than their larger counterparts in exploiting opportunities for engaging in innovative activity.

It is generally accepted that most industrial innovation is generated by the manufacturing sector, but small businesses are less prominent in manufacturing than they are in the three other major industry groups--wholesaling, retailing, and services.^{1/} Therefore, only a relatively small subset of the small-business sector is likely to contribute to industrial innovation. Small businesses in the more specialized, rapidly changing, and high-technology areas of manufacturing--for example, electronics, instrumentation, specialized computers, and sophisticated machinery--may be particularly capable of innovative activity, however.^{2/} Small businesses in wholesaling, retailing, and services are less likely to generate industrial innovations, but as distribution outlets for the results of innovation they serve valuable economic and social purposes.

Members of the small-business community have expressed concern that their ability to innovate is inhibited by a number of Federal policies. The special report by the small-business members of the Advisory Committee of the Domestic Policy Review on Industrial Innovation identified a wide array of Federal policies believed to affect adversely the ability of small businesses to innovate. Specific policies they identified include those having to do with patents, regulation, R&D procurement, and Federal tax,

1/That is, small businesses in the manufacturing sector employ a smaller percentage of all employees than in the three other industry groups. See Nicholas C. Siroplolis, Small Business Management: A Guide to Entrepreneurship (Boston: Houghton Mifflin, 1977), p. 61.

2/H. Stoll and J. Walter, Tax Incentives for Small Businesses (Chicago: Walter E. Heller International Corporation Institute for the Advancement of Small Business, 1980), p. 12.

pension, and Securities and Exchange Commission policies. Similarly, the White House Commission Report on Small Business alleged that the ability of small businesses to play their role in the economy in general and in innovation in particular was being inhibited by current economic policies and Government practices. 1/

Congressional committees in the 96th Congress were very active in response to these concerns. They designed nearly a hundred actions to stimulate the climate for innovation in general and innovation by small businesses in particular. Among actions for the latter were two omnibus bills specifically aimed at fostering innovation in small businesses. Both bills (S. 1860 and H.R. 5607) were entitled "Small Business Innovation Act of 1979," and both were reported out of committee, but neither was passed during the last session of the 96th Congress.

Continuing interest in small-business innovation by the 97th Congress is demonstrated by the introduction of three measures to promote innovation by small businesses. The first of these is H.R. 11, the Small Business Innovation Act of 1981. (This measure is identical to H.R. 5607 from the 96th Congress.) This omnibus bill would establish small-business innovation research programs in Federal agencies, amend the Internal Revenue Code, and amend patent and trademark laws. The two other bills--H.R. 3091 and S. 881--are identical to each other and would establish small-business innovation research programs, modeled after the National Science Foundation's Small Business Innovation Research program, in Federal agencies with research and development budgets in excess of \$100 million. Further interest in the 97th Congress is indicated by its creation of the Subcommittee on Innovation and Technology of the Senate Committee on Small Business.

OBJECTIVE, SCOPE, AND METHODOLOGY

In spite of the active concern about small-business innovation and the significant legislative actions intended to address it, no single study provides a comprehensive picture of small-business innovation. In this report, our objective is to provide a comprehensive picture by showing what factors influence the environment within which small businesses innovate, describing the activities of small businesses as innovators in that environment, and suggesting how an understanding of these can contribute to Federal policymaking efforts to support small businesses as innovators.

1/U.S. Department of Commerce, Advisory Committee on Industrial Innovation: Final Report, September 1979, p. 258. The White House Commission Report on Small Business was issued in April 1980 and was based on the position taken by the 1,682 delegates to the White House Conference on Small Business convened in Washington, D.C., in January 1980.

More specifically, in this report we present three models we developed to display the factors and the relationships among them that result in the environment within which small businesses innovate. We also discuss the two kinds of activities that we have determined small manufacturing businesses undertake to pursue product or process industrial innovations, and we include all economy-wide, industry-specific, and individual-firm factors--common to all potential innovators--that influence the environment within which innovation takes place. Further, we explicate which of the conditions are necessary, which are important, and which are desirable for small businesses to be active in innovation. Finally, having set forth the criteria for judging the efficacy of Federal initiatives to support small-business innovation, we demonstrate the usefulness of the criteria with selected Federal programs whose purpose is to support small businesses as innovators.

We define a small business as one that has 500 employees or fewer and "is independently owned and operated and which is not dominant in its field of operation." (See the Small Business Act as amended, 15 U.S.C. 632 (Supp. III 1979).) We define an industry as a group of firms that share common characteristics, such as those that serve similar markets or share common production functions or common technology. (This is similar to the definition of industries in the Standard Industrial Classification Manual.) We define innovation as a process that begins with the genesis of a technically feasible idea (invention), proceeds with the refinement of the idea (development), and results in the introduction and initial use of new products or processes in the marketplace (commercialization). (See the expanded discussion of this definition beginning on page 7.)

We have not examined the activities of large or medium-sized businesses, university or government laboratories, or other institutions engaged in various stages of the innovation process, nor have we attempted to determine whether small businesses are more important to innovation than other innovators. We have not attempted to determine whether small businesses suffer from any particular disadvantages in their efforts to innovate. We have determined neither whether they are being inhibited by specific Federal policies nor whether the Federal Government should support small-business innovation in preference to supporting the activities of other innovators. We did not evaluate the efficiency or effectiveness of the Federal efforts we selected to demonstrate the use of our criteria.

Finally, we have not attempted to determine the amount or percentage of all innovation deriving from small businesses. This is because only nine studies (those listed in appendix I) attempt to identify the sources of invention and innovation, and all nine have measurement and methodological problems that make interpretation of their combined findings difficult and generalization from them inconclusive. The principal measurement problem is with locating adequate indicators of innovative activity.

Commonly used indicators such as number of scientists and engineers employed, research and development expenditures, number of patents granted, and counts of innovations all present problems in their abilities to accurately quantify innovation. The methodological problems include the size and the methods of selecting samples of innovations, the quite different time spans the studies cover, and variation in the way small businesses are defined. We discuss these measurement and methodological problems in appendix II.

While these measurement and methodological problems preclude quantifying the contributions of small businesses, small businesses are clearly significant contributors to innovation. The nine studies indicate this and so does the broader body of economics and innovation literature that provides information on how small businesses participate in innovation and how the environment influences their participation. Overall, our literature review for this report included:

- comprehensive review of some 175 articles and books having to do with economics and innovation-related topics. This literature covers numerous topics, including capital availability, industrial organization, economic and monetary policy, inflation, entrepreneurship, firm size, regulation, management structure of firms, technology and society, innovation, and patent, procurement, and tax policy. (In appendix III, we present a selected bibliography from this literature.)
- review and analysis of the 9 studies that attempt to identify sources of invention and innovation and, in doing so, address the roles of small businesses in innovation.
- review of numerous executive branch publications having to do with the special problems of small businesses, both generally and as related to innovation.
- review of specific proposals to support innovation by small businesses, including almost 100 specific legislative proposals introduced in the 96th Congress, other proposals contained in President Carter's Industrial Innovation Initiatives, and proposals resulting from the White House Conference on Small Business.
- review of the design of existing Federal activities meant to stimulate or support small-business innovation, including laws passed in the 96th Congress, and a number of programs designed to provide funding or technical and management assistance directly to small businesses.

In addition to studying this literature, we conducted interviews with

--50 small-business owners to obtain their perspectives on the problems small businesses face, both generally and as related to innovation. Among the people we interviewed were representatives from small-business organizations formed to promote innovation by small businesses as well as others not involved in formal organizations.

--more than 25 Federal officials involved in programs designed to support the role of small businesses in general or in innovation in particular as well as a number of other people involved in research on these subjects.

--staff of the House and Senate Small Business Committees and of the House Committee on Science and Technology. All staff members we interviewed had responsibility for innovation policy matters.

We also attended numerous meetings and hearings on small businesses and innovation. Among these were the White House Conference on Small Business, hearings on both the House and Senate versions of the Small Business Innovation Act of 1979 and other bills, and two American Association of Small Research Company conferences, among others.

Performing this research has enabled us to answer three broad questions in this report:

--What influences the environment within which small businesses innovate?

--How do small businesses act as innovators in that environment?

--How can our understanding of the answers to these two questions contribute to Federal policymaking efforts to support small businesses as innovators?

To answer the first of these questions, we developed three models to illustrate the influences of a number of factors on the environment within which small businesses innovate. These models display the economy-wide, industry-specific, and individual-firm factors that were mentioned repeatedly in the literature, interviews, and meetings as having important influences on the environment for innovation. Because the models represent a remarkably complex reality in a simplified way, we have purposely defined the factors in them broadly, and the relationships among the factors remain hypotheses. In chapter 2, we present the factors and explain our models in detail.

Two factors are not represented explicitly in these models, because we consider them to be fundamental to the innovation

process. The entrepreneur's importance in innovation has long been recognized, and we do not discuss it here. Similarly, we acknowledge the profit motive as an important influence on innovative activities in this country, but it is so basic to them that we have not discussed it directly in this report. We have taken entrepreneurship and the pursuit of profit to be implicit elements of the conditions that are conducive to innovation.

With regard to the second question, our data sources indicated that small businesses are most likely to be either primary contributors or complementary contributors to innovation. Which of these kinds of contributor small businesses are most likely to be can be seen as depending on a number of industry-specific variables that include the sophistication of technology, entry barriers (for example, capital intensity, economies of scale), size distribution of firms, and degree of concentration. In different circumstances, some of these variables are more dominant than others. These industry-specific variables are sufficiently correlated with the established, if broad, categories of industry structure that we have used these categories for distinguishing among the activities of small businesses. We list and define the categories of industry structure and discuss the activities of small businesses as innovators in detail in chapter 3.

To address the third question, we drew upon our analysis of the factors that influence the environment for innovation and the activities of small businesses within that environment. In isolating the conditions that are necessary, important, and desirable for innovation to flourish, it became apparent that only some of these conditions are readily amenable to Federal policy manipulation. We developed criteria that are qualitative, not quantitative, indicators for judging the efficacy of Federal initiatives to meet the conditions that support small businesses as innovators. Using these criteria, we demonstrate their usefulness by matching them with the design of selected Federal efforts. We did not evaluate the programs we use to illustrate the usefulness of the criteria.

We demonstrate the use of the criteria with three types of existing Federal policies and programs--those designed to influence economy-wide factors, such as tax or patent policies; those that provide funding to small businesses to support the innovation process; and those that provide technical and management assistance directly to small firms. We demonstrated the use of our criteria with some Federal programs whose specific objective is to support small innovative businesses; we chose only programs already existing or passed into law by the 96th Congress. (These are listed and discussed in chapter 4.) We did not attempt to compile an exhaustive list. It was necessary to limit the programs we subjected to our criteria, because there are many actions that could be expected to influence innovation by small businesses more indirectly, including capital formation measures and programs designed to benefit all small businesses whether they are

innovative or not. Our particular concern is with Federal actions designed specifically to support small businesses as innovators.

We have drawn heavily on the experience of a number of people engaged in small businesses, researchers and academicians, and executive agency personnel who are innovators in their own right, conduct research on the processes of innovation by small businesses, or manage programs designed to support the efforts of small businesses in innovation. We brought these people into our work at different stages, and we involved them in a variety of ways. Small-business people and executive agency personnel helped us during the early stages of our work to identify issues of specific concern to small businesses involved in innovation. They also helped us review the results of our preliminary analysis of the literature in determining what influences the environment for innovation and how small businesses are affected by that environment. Academic and research people helped us later in the project to critique our work and suggested alternative ways of approaching specific conceptual problems. Finally, a group of expert reviewers who had not previously been involved with our analysis provided us with a critique of a preliminary draft of this report.

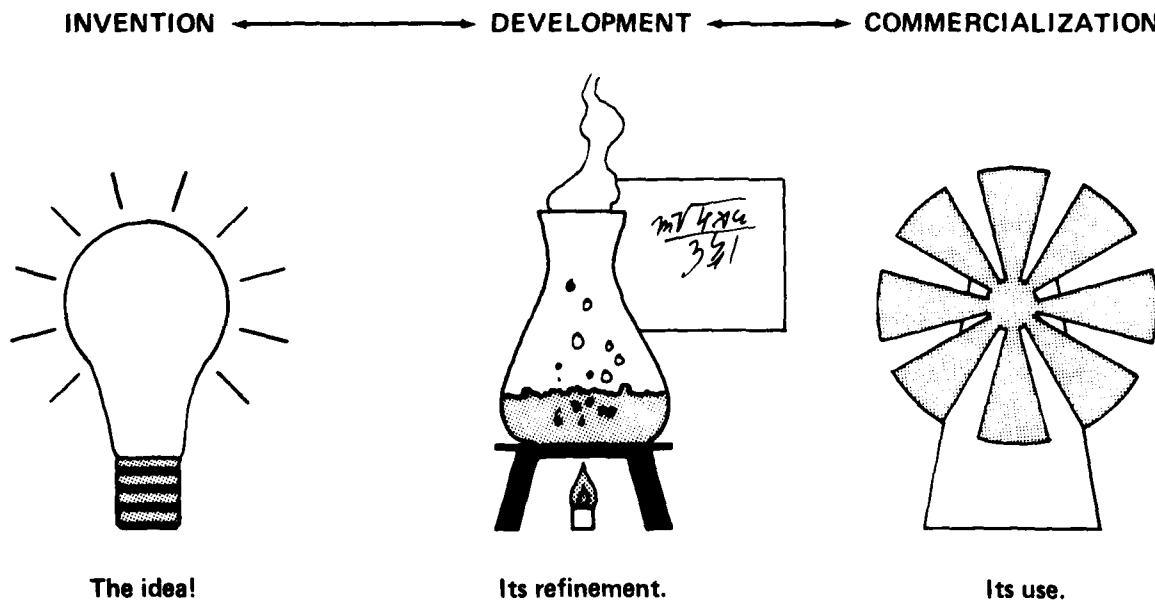
DEFINITION OF INNOVATION

Earlier in this chapter, we defined innovation as a three-stage process. It begins with the genesis of a technically feasible idea (invention), proceeds with the refinement of the idea (development), and results in the introduction and initial use of new products or processes in the marketplace (commercialization). To this definition, we can add the statement that for the innovation process to be activated, two things must exist. One is the idea--an idea that is the result of individual creativity, which is not subject to policy manipulation. The other is a climate that is receptive to the idea.

Actually, there are three related climates within which any small business operates--the climate in the economy as a whole, the climate in the firm's industry, and the climate in the firm itself. We have termed the confluence of these climates the "environment for innovation." By this we mean the combination of the many complex social, political, economic, industrial, technical, and individual factors that encourage and sustain the creation and development of new ideas. The existence of a receptive environment for innovation is vital for the translation of an idea into practice through the innovation process.

Figure 1 on the next page depicts the innovation process. It is a highly simplified picture, because the innovation process is not the linear sequence that the figure implies. Most frequently innovation is iterative, with steps being retraced as knowledge is gained. Innovation is also not continuous. An idea can remain dormant for several years before it is incorporated into a product or process that is introduced into commercial use.

Figure 1
The Stages of Innovation



Each stage of innovation can be characterized by a number of activities and functions, personnel, resources, and results, as depicted in table 1. Reading the table vertically shows the activities and functions, personnel, resources, and results that characterize the three stages of innovation--invention, development, and commercialization. Frequently, different organizations are involved at different stages of the innovation sequence. They may include large businesses, subcontractors, licensees, consultants, universities, government regulatory bodies, financial organizations, and others.

Reading the figure horizontally shows how the activities and functions, personnel, resources, and results necessary to support innovation change as an idea moves from invention through development and finally into commercialization. For example, during invention, very often only minimal resources are required, but during development more sophisticated research equipment is generally needed. It is not unusual for invention to take place in an organization different from the one that develops it. It is also during development that major inflows of capital are often required. Finally, during commercialization, we again see a

Table 1

The Innovation Process--Activities and Functions,
Personnel, Resources, and Results

STAGE	INVENTION The Idea	DEVELOPMENT Refinement	COMMERCIALIZATION Use
ACTIVITIES AND FUNCTIONS 1/	<ul style="list-style-type: none"> -basic research -idea generation -idea evaluation -business/technical feasibility analysis 	<ul style="list-style-type: none"> -applied research -research and development (R&D) 2/ -prototype development -market research, analysis and testing -manufacturing design and pilot production -production planning and production 	<ul style="list-style-type: none"> -licensing -market introduction -advertising -demonstrations -market acceptance
PERSONNEL	<ul style="list-style-type: none"> -individuals or entrepreneurs -research teams 	<ul style="list-style-type: none"> -research teams -marketing, financial, and production specialists -entrepreneurs (or support from an organization) 	<ul style="list-style-type: none"> -entrepreneurs -retail and other outlets -sales representative -maintenance staff -production engineers -labor force
RESOURCES	<ul style="list-style-type: none"> -basic experimental equipment -modest amount of raw materials (chemicals, wire, metal, etc.) -minimum work space -time for experimenting -modest financial resources 	<ul style="list-style-type: none"> -more sophisticated research equipment -sufficient quality of raw materials -experimental and testing facility -capital facilities for manufacturing -financial backing 	<ul style="list-style-type: none"> -markets -plant and equipment inventories -financial backing
RESULTS	<ul style="list-style-type: none"> -a technically viable idea with perceived market potential -new knowledge (nonapplied) 	<ul style="list-style-type: none"> -an operating product or process that has been proven workable and with an identified market -new knowledge (applied) 	<ul style="list-style-type: none"> -new product or process in use by a number of "satisfied" customers"

1/We adapted some components of "activities and functions" from work by the Innovation Center of the University of Oregon.

2/R&D and innovation are often used as synonyms. However, as this table illustrates, we define R&D as one portion of the development stage of the innovation process.

change in resource needs from, for example, raw materials to the plant and equipment necessary to transform them into the end products of the innovation process.

There are four types of innovation--product, process, service, and management. In this report, we are concerned only with product and process innovations. A product innovation results in the introduction of a previously unavailable product or a major improvement in an existing product. A process innovation increases the supply of an already available product, improves the quality or quality control for that product, or reduces the cost of that product. Service and management innovations create improvements in a previous method or service. For example, product innovations often result in significantly better service or more efficient management. This happened with the introduction of both the electric typewriter and the computer into business, for instance.

The distinction between product and process innovations is ambiguous in both theory and practice, however. For example, the product of one firm's innovative activity--a new type of conveyor belt--might be used to improve the process of the user of the innovation--speedier canning or bottling. Given the way we define innovation, we would classify this example as a product innovation originating in one firm even though the innovation is used as a process in the other. In our classification of the sources of innovation, we focus on the creator of the innovation rather than on the user.

ORGANIZATION OF THE REPORT'S TOPICS

In chapter 2, we analyze the factors of the environment for innovation that influence the ability of small businesses to innovate. In chapter 3, we discuss the activities of small businesses in innovation. In chapter 4, we describe the conditions that support small businesses as innovators and, in light of these conditions, we present criteria for judging the extent to which Federal initiatives might enhance innovation in the small-business sector of the U.S. economy. In chapter 4, we also demonstrate the usefulness of these criteria with selected Federal efforts to support small businesses as innovators. Finally, in chapter 5, we summarize our findings and present our conclusions. We also respond in chapter 5 to the major points in comments that the National Science Foundation, the Small Business Administration, and the Department of Commerce made to a draft of this report. Finally, in chapter 5 we make a recommendation to the Congress with respect to the use of the criteria we develop in the report.

Appendix I contains an annotated bibliography of the nine studies that attempt to identify sources of invention and innovation. Appendix II is a discussion of the measurement and methodological problems that make efforts to accurately quantify innovation by small businesses not entirely conclusive. Appendix III contains an extensive but selected bibliography of the vast

literature on economics and innovation. Appendixes IV and V contain descriptions of Federal programs that provide funding and technical and management assistance to small innovative businesses. Appendixes VI through VIII reprint the letters from the agencies commenting on a draft of the report and contain our responses to several specific points we did not believe it was necessary to cover in chapter 5.

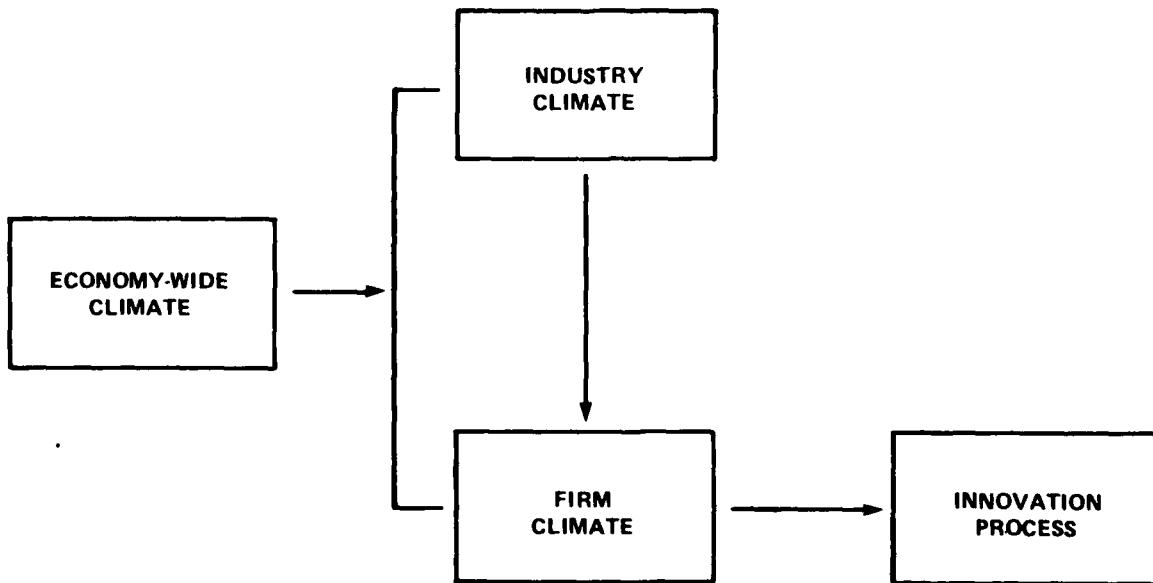
CHAPTER 2

FACTORS THAT INFLUENCE THE ENVIRONMENT FOR INNOVATION

Small businesses innovate in the broad context of the society and the industry in which they operate. This broad context, which we refer to as the environment for innovation, is made up of a number of factors that are identified consistently as important influences on innovation. The factors combine into three groups--economy-wide factors, industry-specific factors, and individual-firm factors--and we refer to each group of factors as a climate. Together these three climates form the environment (the context) that will either support or inhibit the ability of small businesses to innovate.

In this chapter, we describe the individual climates within the economy, industry, and firm as they combine to form the overall environment for innovation. That is, we identify the factors that make up these three climates. Then we discuss their influence in determining the likelihood that innovation will take place.

Figure 2
**The Three Climates for Innovation
and Their Relation to the Innovation Process**



THE ENVIRONMENT FOR INNOVATION

The relationships among the factors in the economy, the industry, and the firm establish the environment for innovation within which a small business functions. We have constructed four models for understanding the interactions of these factors. Three models depict the relationships among the factors within each group; the fourth model depicts the relationships between these three models and the innovation process. Figure 2 gives an overview of all these relationships. The models are simplifications of the complex influences on the environment within which small businesses innovate. In the text that follows, we discuss the factors of each climate in turn.

Factors in the climate of the economy

In the economy, ten factors influence the climate for innovation. They are world conditions, the social context, the economic context, political action, government policy, changes in social and economic contexts, barriers, incentives, incentives balance, and optimism/pessimism. These factors are defined in table 2, and the linkages we assume among them are illustrated in figure 3.

Figure 3
The Economy-Wide Model

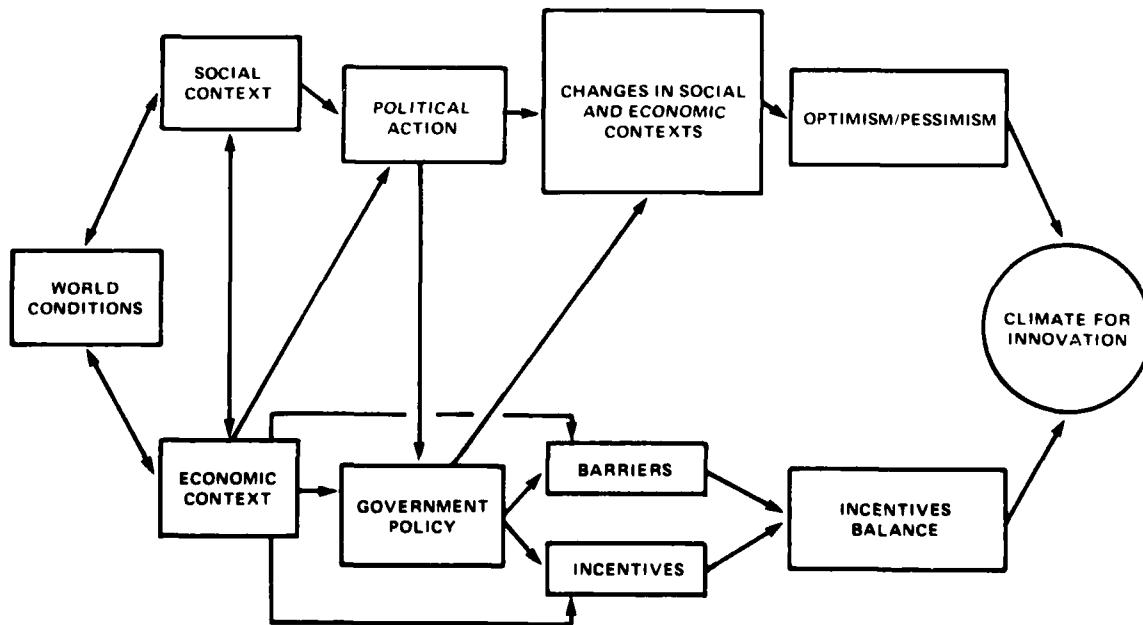


Table 2

The Economy-wide Factors That Influence
the Climate for Innovation

=====

- World Conditions: The political, economic, social, and physical circumstances prevalent in the world at a given time.
- Social Context: The sum of social desires, values, and needs exhibited in a society--such as pressures for a clean environment, demand for energy, need for defense strength--that establish the mood of the society at a given time.
- Economic Context: The set of economic influences on society including inflation, availability of capital, total demand for goods and services produced in the economy (aggregate demand), and uncertainty and questionable economic stability.
- Political Action: The set of preferences exhibited and pressures exerted by individuals, special interest groups, the press, and other segments of the society that influence changes within the society.
- Government Policy: Legislative and executive actions taken in response to conditions in the social and economic contexts and political action, including specific tax, patent, regulatory, and procurement policies.
- Changes in Social and Economic Contexts: Actual modification in or the perception of modification in the social or economic contexts.
- Barriers: Perceived or real blocks to one or more of the stages of innovation (invention, development, commercialization), such as an uncertain regulatory environment, problems of failing patent protection, or lack of financial resources.
- Incentives: Stimuli to or positive supports for innovative activity, such as tax loss benefits, high financial return on investment, or direct government subsidy.
- Incentives Balance: The balance between incentives and barriers to innovation as judged by an individual decisionmaker.
- Optimism/Pessimism: People's belief that social or economic conditions are good or improving or are bad or deteriorating.

=====

Some of the relationships are generally acknowledged. For example, most people would agree that world conditions shape and are shaped by the social and economic contexts in the United States. Similarly, the social context stimulates political action, which in turn influences government policy and can bring about changes in the social and economic contexts. Equally well known but perhaps less frequently acknowledged is that these interactions result in the degree of social and political optimism or pessimism prevailing at any given point in time.

Both the economic context and government policies act as either incentives or barriers to innovation. Incentives might include patent protection, certain types of tax policy, or the promise of profits. Barriers might include concerns about an uncertain regulatory environment or uncertainty in economic outlook. The combination of the numerous individual incentives and barriers forms what we call an incentives balance. The balance of incentives and barriers has its origins in the social and economic contexts, of course. The social and economic contexts in turn influence political action, government policy, and the incentives and barriers.

The economy-wide model shows that the interactions among these ten factors produce the economy-wide climate for innovation. The incentives balance and the degree of optimism or pessimism are shown as affecting the climate directly; the eight other factors appear to exert their influence more indirectly, being mediated by the others. Moreover, the economy-wide climate for innovation establishes the overall climate within which all industries operate. Each industry, however, is affected differently from every other industry by the different economy-wide factors.

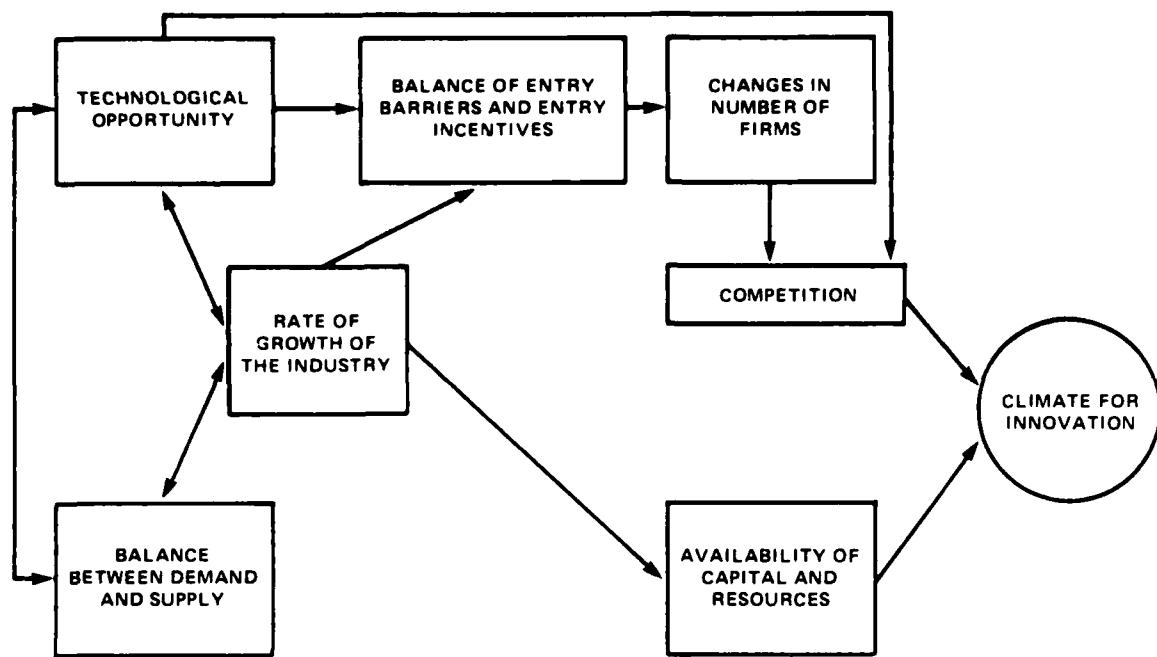
Factors in the climate of the industry

Seven factors influence the climate for innovation in an industry. They are growth rate of the industry, technological opportunity, competition, balance between demand and supply, balance between entry barriers and entry incentives, changes in the number of firms, and availability of capital and other resources. These are defined in table 3, and the linkages we assume among them are illustrated in figure 4 (on the next page).

The degree of technological opportunity, the rate of growth, and the balance between demand and supply in an industry mutually influence each other. Exploitable technological opportunity is likely to stimulate an industry's rate of growth. Similarly, a positive rate of growth is likely to modify the balance between demand and supply, which in turn will influence technological opportunity, though to a lesser extent. These three factors also tend to indicate the maturity of an industry.

The growth rate of an industry has an important influence on the availability of capital and resources. Too rapid growth can cause serious cash flow problems for the firms in an industry and

Figure 4
The Industry Model



hence can inhibit the availability of internally generated funds. Even so, rapid growth may be expected to attract external capital in exchange for a promise of increased future value. A steady growth rate should produce sufficient profits to provide internal sources of capital.

The availability of capital, however, is only one of several important ingredients for a positive climate for innovation. Capital alone will not spark innovation. The presence of exploitable technological opportunity is likely to make firms in that industry better able to attract external sources of capital, because of the promise of future growth in the industry. That is, implicit in the availability of capital and resources is the concept of profitability. Innovative projects will not be undertaken if they are not expected to yield the return on investment required by the firms initiating the projects. Of the three stages of the innovation process, invention is the least likely to be constrained by profitability considerations. The development and commercialization of innovations, however, are certainly tied to the promise of future profits.

While the state of technology and technological opportunity vary drastically from industry to industry, within any one industry

Table 3

The Industry-Specific Factors That Influence
the Climate for Innovation

- Growth Rate of the Industry: Increases in the output of an industry, as indicated by increases in sales or in "value-added."
- Technological Opportunity: The extent to which generic technologies, basic scientific theories, and technological know-how can be put to new use in and be exploited by an industry.
- Competition: The degree of rivalry among firms, through either markets or technology.
- Balance Between Demand and Supply: The relationship, for society as a whole, between the demand for particular resources or products and the supply of resources or products.
- Balance of Entry Barriers and Entry Incentives: The sum of restraints and stimuli to the entrance of new firms into an industry, such as capital requirements, the extent of product differentiation, economies of scale, and industry-specific regulation.
- Changes in the Number of Firms: Increases or decreases in the total number of firms operating in a given industry.
- Availability of Capital and Resources: The extent to which the firms in an industry have access to capital, whether internally generated through profits or externally attracted by the promise of increasing future value of the firm's output. Also, the extent to which the firms in an industry have access to needed raw materials, labor, specialized scientists and engineers, and the like.

they influence its climate for innovation by influencing its rate of growth, the balance of entry barriers and entry incentives, and its competitive position. The genetic engineering industry exemplifies the emergence and growth of an entirely new industry because of the influence of technological opportunity. But if technological opportunity influences growth rate, the reverse is also true. An industry's growth and expansion are likely to

stimulate the development of new or the exploitation of existing technology. 1/

Finally, the degree of technological opportunity affects competition, both directly and as mediated by the balance of entry barriers and entry incentives. The emerging genetic engineering industry is still a useful example. Technology is changing rapidly in that industry, the potential payoff from exploiting that technology is great, and the result is very active competition among a number of new small firms.

Competition is a critical factor in influencing the climate for innovation within an industry. Rivalry stimulates firms to stay ahead of other firms in the same industry and thus may prompt them to fund innovative activities to develop or modify products or processes. Development and modification by definition almost always involve innovative activities. Competition, however, does not have a single, always predictable influence on the climate for innovation. Excessive competition may diminish the ability of firms to finance innovation, by forcing them to use resources to finance short term, defensive activities.

The influence of competition on the climate for innovation is quite different from industry to industry. More mature industries within which only a small number of relatively large firms compete may be spurred to innovate by competitive pressure or may lapse into innovative complacency. Industries in which a large number of small firms compete are theoretically the most competitive, but they may include firms without financial power sufficient to support innovation beyond initial invention and development.

No single level of competition is most likely to influence positively the climate for innovation. It appears clear, however, that the absence of market or technological competition dampens profoundly the industry climate for innovation. Excessive competition may also impede innovation.

As the industry model shows, the interactions among its seven factors determine the climate for innovation within individual industries. This dynamic makes it difficult to generalize about the conditions that must hold if the climate for innovation is to be positive, but we do know that some conditions are likely to be common. For example, the absence of technological opportunity is likely to dampen the climate for innovation substantially. Additionally, scientific or technical breakthroughs can create technological opportunity where it had not previously existed. Finally, a positive growth rate is conducive to innovation insofar as that growth results in capital that is generated through profits or attracted from outside the industry.

1/J. H. Schmookler, *Invention and Economic Growth* (Cambridge: Harvard University Press, 1966).

It is less easy to characterize the degree of competition that is most conducive to innovation in an industry. It seems clear, however, that excessive competition tends to divert resources into defensive actions and to focus business activities on such areas as product differentiation and imitation. It tends to divert resources away from the more offensive strategies that would help identify innovation as a way of achieving competitive advantage. Too little competition may provide little incentive to innovation and hence may dampen the climate for it.

Factors in the climate of the firm

Six factors contribute to creating the climate for innovation within an individual firm. They are technological opportunity, strategy, structure, maturity, size, and availability of resources. These are defined in table 4 (on the next page), and the linkages we assume among them are illustrated in figure 5.

Like the others, the firm model represents a complicated set of mutual influences. The existence of technological opportunity is vital in establishing a positive climate for innovation within a firm. An individual firm's structure and strategy--including the presence or absence of an entrepreneur--are most likely to determine the extent to which it can identify and exploit

Figure 5
The Firm Model

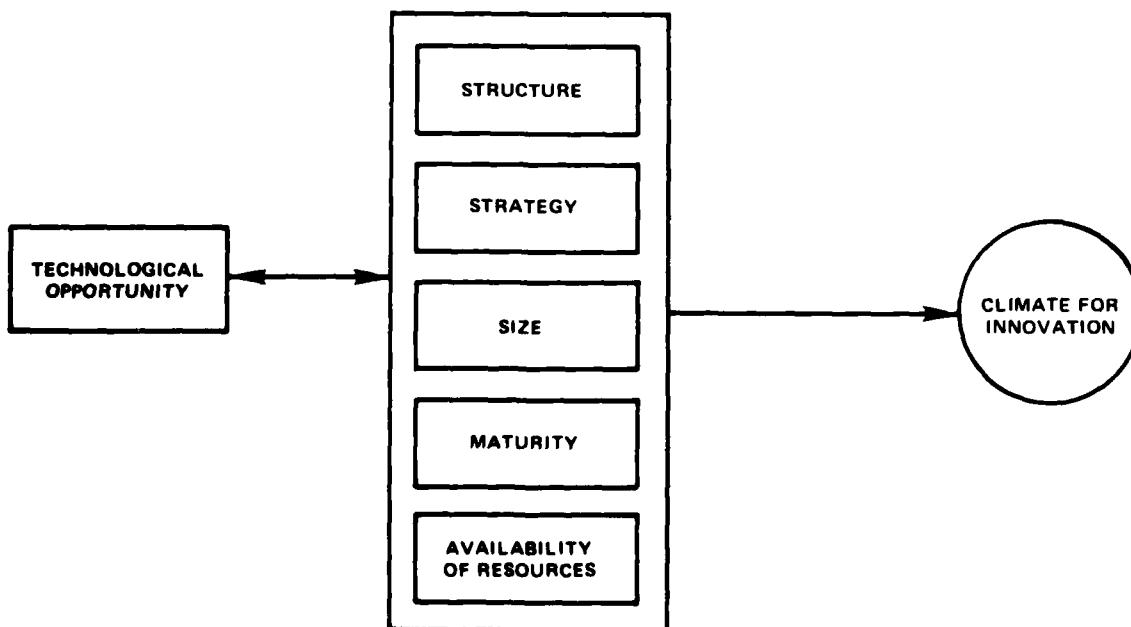


Table 4

The Firm Factors That Influence
the Climate for Innovation

=====

- Technological Opportunity: The extent to which generic technologies, basic scientific theories, and technological know-how can be put to new use in and be exploited by an individual firm.
- Strategy: The purpose, objectives, market, and risk preference of a firm.
- Structure: The mix of management structure, presence or absence of an entrepreneur, technical and scientific capabilities, skills of managers, the source of control of the organization (whether it resides inside or outside the firm), the firm's competitive situation, and the degree to which communication among firm members can be easily accomplished.
- Maturity: The extent to which a firm has established a relatively stable market base, has a relatively consistent and modest rate of growth, and commits the majority of firm resources to maintaining that established market share and growth rate.
- Size: The number of employees, gross or net sales, number of scientists employed, or other measure of the size of an organization.
- Availability of Resources: The extent to which a firm has access to financial and human resources that it can commit to innovative activities, whether internally or externally generated.

=====

technological opportunity. Cumbersome communication within a firm may threaten the survival of its new ideas. In organizations in which the people who have ideas also have access to the people who make resource allocation decisions, good ideas have a greater chance of survival. Firms that favor risk-taking are more likely to pursue innovative activities than firms that do not.

Size, of course, affects structure and strategy. Where there are few employees, they can communicate easily; as firms grow larger, management structure and rules are introduced to govern behavior and tend to inhibit communication. When management structures are rigid, rules are imposed, and roles are specified, innovation is likely to be impeded. This is true not only of individual firms but of autonomous units operating within large organizations.

The maturity of a firm is by itself less important as an influence on its climate for innovation than are the other firm-specific factors. A more mature firm may possess a degree of organizational stability that provides it with a solid base from which to venture into new endeavors. The opposite may also be true, however, inasmuch as more mature firms tend to be more averse to risk than newer firms.

All the other individual-firm factors exert influence on the access of a firm to necessary resources. A more successful firm may have generated sufficient financial resources to cover operating expenses, provide profit, and retain some reserve for new endeavors. On the other hand, it is just as likely that a successful firm will grow too fast. Rapid growth can leave it with an inadequate cash flow and present a questionable financial picture that makes attracting external financing difficult. The availability of financial resources allows the firm to acquire other necessary resources, such as the services of specialized personnel, scientists, and managers.

The firm model shows the interactions among these six factors as they determine the climate for innovation within an individual firm. There are so many mutual interactions among the factors at this level, however, that the majority of them are not even depicted in the model. Because the conditions within individual firms are so variable, few generalizations can be made about the nature of these factors or how they combine to make a positive climate for innovation. We do know, however, that for a firm to be innovative it must be able to identify exploitable technological opportunity and have access to resources and an entrepreneur or manager to exploit the opportunity.

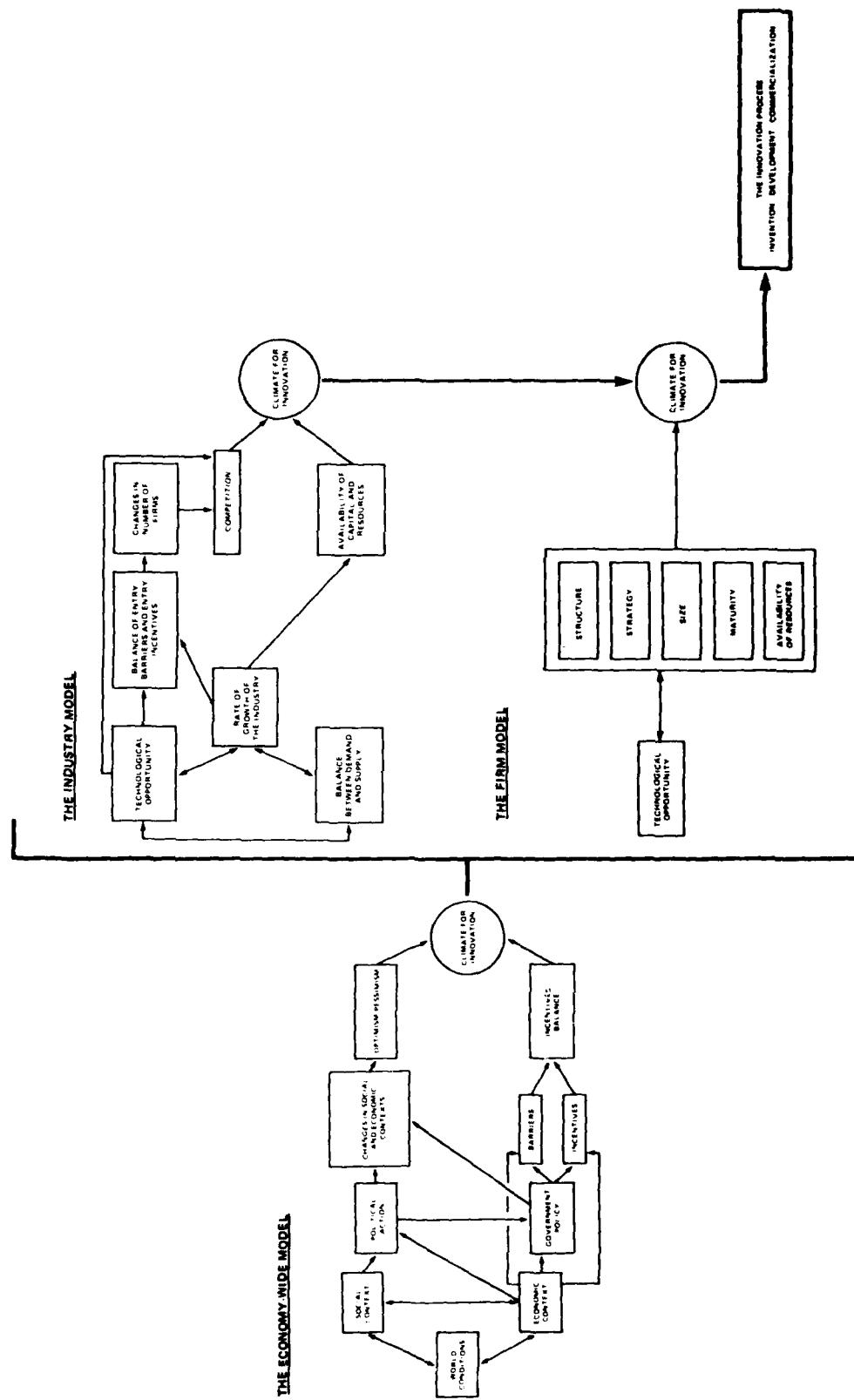
THE ENVIRONMENT AS A DETERMINANT OF INNOVATION

The economy-wide climate for innovation combines with the climates in the industry and the firm to determine the general environment for innovation. Recall that in chapter 1 we defined the environment for innovation as the combination of the many complex social, political, economic, industrial, technical, and individual factors that encourage and sustain the creation and development of new ideas. As we use it here, the environment for innovation is the combination of the economy-wide, industry, and firm climates for innovation. On the next page, we illustrate the relationships among these climates as they combine to influence the environment in general and the innovation process in particular.

The economy-wide climate for innovation sets the context within which all industries and firms operate. Similarly, the climate of the industry sets the context for each firm in that industry. The climate for innovation within any given firm, then, results from the combination of factors in that firm, the climate in the industry in which the firm operates, and the broader economy-wide climate that affects both the industry and the firm.

Figure 6

The Relationships Between the Economy-Wide, Industry, and Firm Models and the Innovation Process



The innovation process is initiated by individuals or entrepreneurs within a firm. If a positive environment for innovation exists within a firm and if it perceives the economy-wide and industry climates as either at least neutral or somewhat conducive to innovation, then it is possible that the firm will innovate. The firm model depicts the climate for innovation for an individual firm, not for a class of firms such as all small businesses. No climate for innovation is common to a whole class of firms.

This is not to say that innovation will occur in a firm if the climate for innovation in that firm is positive. It is to say simply that innovation is more likely to occur. No matter how positive a firm's climate is, innovation will occur only in the presence of a new idea, the genesis of which is not subject to policy manipulation. If the firm's climate for innovation is negative, however, innovation is unlikely to occur in that firm even if the economy-wide and industry climates for innovation are positive.

Size by itself does not make a small firm any more likely to be innovative than its larger counterparts. Nevertheless, small size is correlated with flexibility, motivation, opportunity, and interest in small markets. This may partially account for the ability of small businesses to be innovative. It is crucial that the climate for innovation within an individual firm be positive if innovation is to occur, but that climate is very fragile and can fluctuate greatly as the factors that influence it change.

In an industry, innovation is not likely if the climate in that industry is negative. A positive industry climate does not make innovation happen but may stimulate it. A positive industry climate can overpower a negative economy-wide climate and result in innovative activity in one industry at a time when other industries have abandoned innovative activities. Industries evaluate economy-wide factors in different ways, which accounts for wide variations in innovative activity at any one time. A negative climate within an industry, however, is likely to counteract both positive economy-wide and positive firm climates and, hence, essentially preclude innovation in that industry.

While a positive economy-wide climate for innovation helps make innovation possible and increases the probability that some innovation will occur, it will not result in innovation unless an individual firm in a given industry decides to innovate. An unfavorable economy-wide climate for innovation can, however, be so pervasive as to inhibit innovation by altering the climates in both the industry and the firm. All industries are affected differently by certain factors in the economy-wide climate for innovation. This means that, even in times of a generally perceived negative economy-wide climate, innovation will take place in some isolated industries. The primary effect of a negative economy-wide climate for innovation is that it inhibits innovation in ways that are likely to prevent widespread, active innovation across all industries.

CHAPTER 3

SMALL BUSINESSES AS PARTICIPANTS IN INNOVATION

The activities of small businesses in innovation vary according to the nature of the industry in which they operate and the technology employed in that industry. The activities of other participants in the innovation process--medium-sized and big businesses, university and government laboratories, and organizations of other kinds--also differ according to industry and technology. In this chapter, we focus on the ways that small businesses are most likely to participate in innovation in each of four broad categories of industry structure. In addition, we discuss the special roles of new small businesses and emerging industries.

THE VARIATION OF SMALL-BUSINESS ACTIVITY FROM INDUSTRY TO INDUSTRY

Small businesses can be expected to be active in innovation in one of two ways. Any given firm might behave as a

--primary contributor, when small businesses are responsible for the majority of all innovation in an industry or sector, or as a

--complementary contributor, when small businesses serve as either

feeders, or specialized contributors, tending to develop innovations to solve problems or needs defined by government or another business, or

spawners, when they bear the initial risk of a new idea and are then purchased by or sell the technology to another organization.

A number of industry-specific factors determine which of these ways small businesses are likely to act in a given industry. These factors include the sophistication of technology employed in the industry and its entry barriers, economies of scale, capital intensity, and how easy it is to imitate innovation. These variables differ from industry to industry in the way they influence innovation in small businesses.

It is generally accepted in the economics literature that there is a correlation between the factors listed in the paragraph above and four commonly used categories of industry structure. We use these four categories, as described below, to help distinguish small businesses as innovators.

--Atomistic industries are composed of a large number of small firms. Individual firms have only a minimal effect on the industry as a whole, and there are quite

low entry barriers. The printing, oil exploration and drilling equipment, and tool and die industries are examples.

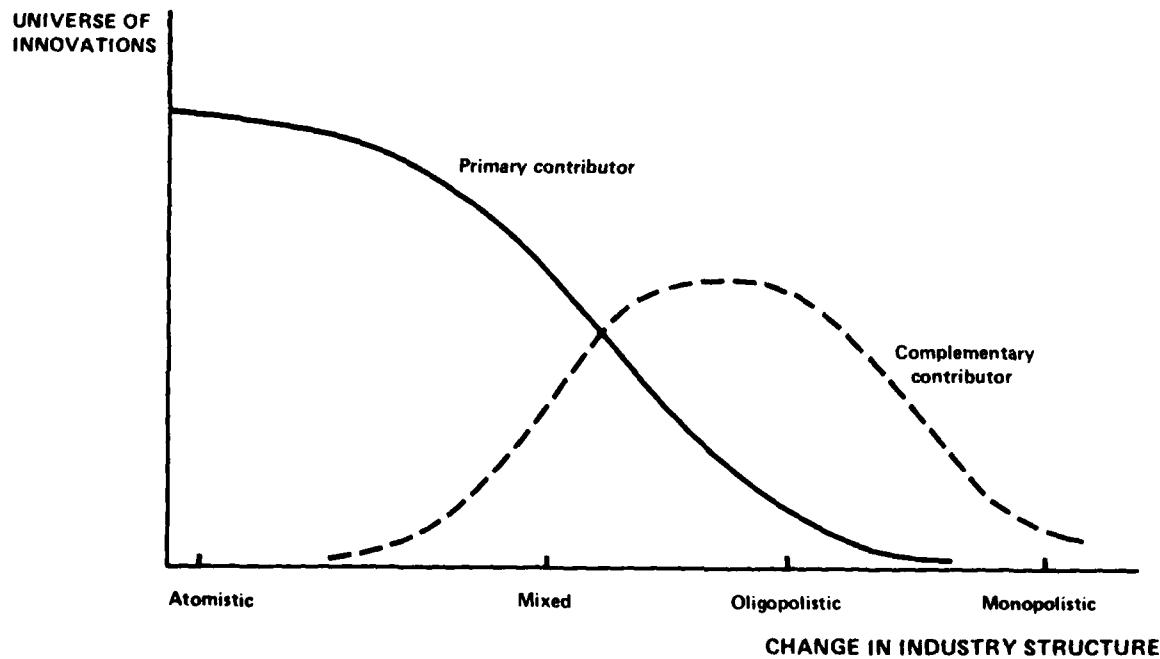
--Mixed industries are composed of some large and some small firms. Entry barriers are generally modest. Apparel manufacturing, food processing, and manufacturing of specialized instruments are examples.

--Oligopolistic industries are composed of a small number of usually larger firms. There are likely to be significant entry barriers, and individual firm actions may stimulate change in the industry as a whole. Examples include petroleum refining, automobile manufacturing, and tobacco products.

--Monopolistic industries are composed of one or a few firms selling a homogeneous product. Entry barriers are generally quite high. While no pure monopolies exist, in some regions cement may be considered a monopoly, as might be the manufacture of certain products protected by patents (for example, instant development cameras by Polaroid).

Figure 7

The Activities of Small Businesses
in Different Industry Structures



The innovative activities of small businesses in industries change as the structure of industry changes, more industries become concentrated, and technology becomes more capital intensive. Figure 7 illustrates how they may be expected to change, given this characterization. (The figure shows behavioral expectations implied by our framework and is not based on actual data or quantified levels of contribution.)

In atomistic industries, which are characterized by low entry barriers and low capital intensity, small businesses are most likely to be primary contributors. In these industries, small businesses are generally able to assemble the requisite personnel and resources to perform the activities and functions at each stage of the innovation process. Small businesses, then, are likely to generate both product and process innovations in those industries. 1/

In mixed industries, where small firms must compete with larger firms, small businesses are more likely to be complementary rather than primary contributors, as either specialized contributors or spawners. This is because the small firms in these industries are more likely than the larger firms to have difficulty assembling the requisite personnel and other resources required to carry out all three stages of the innovation process. Further, in mixed industries there are economies of scale in personnel, equipment, and facilities, especially in the R&D portion of innovation, and many small firms simply cannot take advantage of these. 2/

Small firms as complementary contributors may act as either specialized contributors or spawners. When small firms act as specialized contributors, developing products designed to serve a specified need, their innovations are frequently components or subcomponents of larger systems. As a spawner, a small firm might have an invention that requires expensive and rigorous development beyond the human and financial resources available to the firm. If the firm sells the invention to another, usually larger organization that can afford to support the development and commercialization stages of the innovation process, then the small firm is a spawner.

1/Morton I. Kamien and Nancy L. Schwartz concluded that "Small firms contribute more than their proportionate share of innovation in industries characterized by low entry costs and low capital intensity . . ." ("Market Structure and Innovation: A Survey," *Journal of Economic Literature*, 13 (1975), 19).

2/This tends to explain why the majority of formal R&D in this country is performed by large firms. For a detailed discussion of this conclusion, see, for example, J. Jewkes et al., *Sources of Invention* (New York: W. W. Norton & Co., 1969), pp. 123 ff.

The innovations resulting from small businesses acting as complementary contributors are most likely to be products specifically designed to serve a particular need or a particular segment of a market. In a mixed industry, small businesses are less likely to generate process innovations, because the impetus for process innovations lies in production economies that are often minimal per unit of output. Many small firms simply do not have sufficient output to justify the development of process innovations, even though the products they produce are frequently used in the processes of some other organization.

Acting as specialized contributors or spawners often makes small businesses visible and attractive purchase options to other organizations that want to diversify or expand current markets. Such purchases also satisfy the small-firm owner's desire for the financial reward for developing ideas.

As markets become large, industries become more concentrated and capital intensity and entry barriers increase. Oligopolies and monopolies emerge. In such situations, small businesses are most likely to be complementary contributors to innovation. While small businesses may be less actively involved in innovation in these industries than in less concentrated ones, most concentrated industries have an atomistic sector that serves the larger firms in the industry. Small businesses may be quite active in this sector. For example, an atomistic sector of the petroleum industry (an oligopoly) provides specialized drilling equipment for oil exploration, and an atomistic sector of the automobile industry might contribute new types of electronic instrumentation or controls. To the extent that small businesses play a role in highly concentrated industries, they are likely to function as specialized contributors and contribute product innovations, which are often used in the processes of larger firms in those industries.

THE SPECIAL CASE OF NEW SMALL BUSINESSES AND EMERGING INDUSTRIES

Frequently, new small businesses emerge to exploit technological opportunity and small markets by developing innovations and, in doing so, generate important social and economic benefits. While a positive climate for innovation within an industry is likely to stimulate the creation of new firms, we cannot predict the factors that will be the most influential in stimulating the formation of new firms. It would appear, however, that in the specific case of industries in which the technology is not capital intensive, and the potential market is relatively small, the presence of technological opportunity could be expected to stimulate the development of new firms or even emerging industry offshoots.

Small businesses and individual inventors have been responsible for some of the most well-known technological breakthroughs of this century. These include Charles Carlson's development of

xerography, Sir Frank Whittle's work on jet engines, and Frederick G. Banting's discovery of insulin. These breakthroughs, however, cannot be attributed to any quality necessarily inherent in smallness. They resulted from a convergence of talent, resources, and technological opportunity.

While it is vital for new firms to be promoted by an entrepreneur, an inventor, or a manager, the formation and growth of new firms can be influenced by factors external to these individuals. The factors might include scientific discoveries, new applications for existing technologies, or the availability of adequate resources.

There is a complex and dynamic relationship between larger established firms and new firms created as spin-offs. Spin-offs occur when an individual scientist or entrepreneur leaves a parent company, often with some sponsorship by the parent, to develop an invention or innovation that generally is not compatible with the products or markets of the parent, would not ensure adequate return on investment for the parent, or is too risky for the parent to undertake.

Case studies of the creation of new firms have found very little commonality in their conditions. It is, therefore, unrealistic to attempt to predict what factors are most likely to stimulate the creation of new firms. For the same reason, it is unrealistic to predict the attendant development of emerging industries.

CHAPTER 4

CONDITIONS THAT SUPPORT SMALL BUSINESSES AS INNOVATORS

Our analysis of the factors that influence the environment for innovation and the activities of small businesses within that environment (discussed in chapters 2 and 3) allows us to isolate the conditions that allow innovation to flourish. Few people would disagree that it would be ideal if the economy-wide, industry-specific, and firm climates for innovation were all positive. A strong and growing economy, a positive incentives balance, the presence of technological opportunity, the availability of resources, and balanced competition within industries would all contribute to an ideal state. The ideal, however, is neither obtainable nor necessary. A number of conditions, if present, make it more likely that small businesses will innovate.

In this chapter, we do the following things. We describe the conditions that are necessary, that are important, and that are desirable for small businesses to be active in innovation, and we show which of these conditions are amenable to policy manipulation. Given these conditions, we present criteria we developed for judging the efficacy of Federal initiatives designed to support small-business innovation. These criteria are qualitative, not quantitative, indicators of the conditions conducive to innovation. We demonstrate the usefulness of these criteria with selected Federal efforts to support the actions of small businesses as innovators.

CONDITIONS THAT SUPPORT INNOVATION

If a small firm is to be active and successful in innovation, it is necessary that the climate for innovation within the firm be positive, because the decision to innovate is made within each individual firm. A positive climate is most likely to result from some combination of technological opportunity and an entrepreneur to exploit it, a strategy meant to promote innovation, and a structure that allows its implementation. In addition to working within a positive climate for innovation, a firm should also be capable of producing the innovation at a cost that makes it competitive with substitute goods and contributes profits to the firm. Moreover, the firm should be able to compete successfully with other firms in an industry. This is most likely to happen in atomistic industries or sectors. Finally, if a small firm is to successfully complete the innovation process, the firm will need access to resources throughout all phases of the innovation process, and the result of the firm's innovative activities must be introduced into commercial use.

A positive industry climate for innovation is important for small-business innovation, but it is not as necessary as a positive firm climate. A positive industry climate will support ongoing innovative activities, and it may also stimulate new innovation and encourage the formation of new firms within the

Table 5

Conditions Necessary, Important,
and Desirable to Support Innovative
Activities of Small Businesses

NECESSARY CONDITIONS

A positive climate for innovation within an individual firm, characterized by:

- technological opportunity,
- a pro-innovation strategy and a structure that allows its implementation, and
- the technical, managerial, and financial resources necessary to exploit the technological opportunity;

An industry structure in which an individual firm can function as either a primary or a complementary contributor to innovation, characterized by:

- industries or sectors of industries that are not capital intensive or that have low entry barriers (for example, an atomistic industry or atomistic sector of an industry) or
- industries that have needs for specialized products produced on a small scale.

IMPORTANT CONDITIONS

A positive climate for innovation within the industry in which the small firm operates, characterized by:

- existing or developing technological opportunity and
- resources available to exploit that opportunity.

DESIRABLE CONDITIONS

A positive economy-wide climate for innovation, characterized by:

- more incentives than barriers to innovation and
- a state of social, political, and economic optimism.

industry or attract established firms to enter the industry. A positive industry climate conducive to small-business innovation is most likely to exist in an industry that has technological opportunity and resources available to exploit that opportunity as well as competition in the industry that is balanced--neither excessive nor stagnant.

Finally, for innovation to occur, it is desirable but less important that the economy-wide climate for innovation be posi-

tive. A positive economy-wide climate is not as important, because a positive industry climate can overpower a negative economy-wide climate and result in innovation in one industry at times when other industries have abandoned innovative activities. Similarly, individual firms can combat a generally perceived negative economy-wide climate and innovate despite relatively unfavorable conditions. Remarkable advances in electronics in recent years demonstrate this. A positive economy-wide climate is most likely to result if more incentives than barriers to innovation exist (that is, when there is a positive incentives balance) and if social, economic, and political optimism exist.

We see, then, that if an individual small firm is to develop and commercialize innovations, it is necessary that it have a positive climate for innovation as well as access to adequate resources. It is important but not as necessary as a positive firm climate for the climate for innovation within the industry to be positive. And it is desirable, but not as important, for the economy-wide climate for innovation to be positive. Table 5 summarizes the conditions that are necessary, that are important, and that are desirable for innovation to occur in small businesses.

CONDITIONS AMENABLE TO POLICY ACTION

The conditions that encourage small businesses to be active in innovation result from the interactions of a number of factors. They are the economy-wide, industry-specific, and individual-firm factors we discussed in chapter 2. However, only some of the factors that influence the economy-wide and industry climates are readily amenable to Government policy influence. Moreover, few factors within an individual firm are directly subject to policy manipulation, although the firm's climate is affected by changes in the economy and the industry.

Incentives and barriers are the only economy-wide factors that are readily amenable to policy influence. As we discussed in chapter 2, incentives stimulate or support innovative activity and include tax loss carrybacks, patent protection, and certain procurement policies, among others. Barriers are real or perceived blocks to one or more of the stages of innovation (invention, development, commercialization), such as an uncertain regulatory environment or economic outlook.

Efforts to influence incentives and barriers present problems to the policymaker, however, because what is an incentive to one industry or firm may be a barrier to others. For example, certain regulations intended to control industrial pollution erect barriers in some manufacturing industries while serving as incentives to the development of innovative abatement technologies in others. Also, regulatory impact often apportions a higher proportionate cost to small businesses than to larger businesses. Similarly, a particular policy action, such as establishing certain tax incentives, may be an incentive to only a small set of firms in all industries. For example, allowing reductions in taxable income for research and development expenditures will benefit primarily

firms that sponsor formal R&D. Many small businesses do not conduct formal R&D, segregate expenditures that might be defined as R&D expenditures, or have adequate profits against which to offset a tax deduction. These small businesses would, consequently, not benefit from R&D tax deduction provisions.

The economy-wide climate for innovation is most directly influenced by the degree of optimism or pessimism and the incentives balance. Examining these factors in our economy-wide model in chapter 2 (figure 3) shows that optimism and pessimism are important determinants of the economy-wide climate for innovation, but they can be affected only indirectly by policy actions that change the social, political, and economic contexts. Individual incentives and barriers to innovation that produce the incentives balance are an important influence and can be affected by Government policy.

The climate for innovation within an industry is influenced by three factors that are sensitive to policy manipulation--the availability of resources, technological opportunity, and the balance between demand and supply. The industry's rate of growth and competition and its balance of entry barriers and entry incentives are less responsive to policy changes and exert less influence on the climate for innovation within an industry (chapter 2, figure 4). Thus, although these latter three factors could be influenced by Federal policy actions, they are less appropriate targets for policy manipulation.

Most of the factors that influence the climate for innovation within an individual firm--size, structure, strategy, maturity--are not as directly subject to policy manipulation as are availability of resources and technological opportunity, which can be influenced specifically by Federal policy initiatives. Actions directed toward economy-wide and industry-specific factors also affect individual firms. How much they affect the likelihood that small businesses will innovate is hard to predict.

CRITERIA FOR FEDERAL INITIATIVES
TO IMPROVE CONDITIONS
THAT SUPPORT INNOVATION

Analysis of the conditions that are necessary, important, and desirable for small businesses to be active in innovation has enabled us to develop criteria for judging the efficacy of Federal initiatives in meeting these conditions. No single initiative could be expected to meet all the criteria. We demonstrate the usefulness of the criteria with three types of Federal actions to determine the extent to which the actions address the conditions that support small businesses as innovators.

To meet the conditions necessary to the activities of small businesses as innovators, Federal initiatives should be designed so that they

- encourage exploitation of technological opportunity,
- provide mechanisms to ensure that a firm sponsoring an innovation has the managerial and technical capacity to support it at each stage of the process (invention, development, and commercialization),
- provide mechanisms to ensure that financial and human resources adequate to support innovation at each stage of the process are available to the firm, and
- encourage innovation in technologies or industries in which small businesses can be expected to assemble the resources necessary to support each stage of the innovation process (as in industries in which small businesses would function as primary or complementary contributors).

To meet conditions important to small businesses as innovators, Federal initiatives to influence the climates for innovation within industries should be designed to

- stimulate the creation of technological opportunity or augment existing technological opportunity (as might be accomplished with technology transfer programs or by supporting basic research, R&D, or generic technologies) and
- provide mechanisms to increase the availability of financial and human resources.

To meet conditions desirable to small businesses as innovators, Federal initiatives to influence the economy-wide climate for innovation should

- address enough incentives and barriers to alter the balance between them in a positive way (by comprehensive efforts that might include initiatives to reduce the rate of inflation, provide tax or patent incentives, and reduce or eliminate barriers created through regulation).

FEDERAL ACTIVITIES TO SUPPORT SMALL BUSINESSES AS INNOVATORS

Federal efforts to support the activities of small businesses as innovators are generally of three types--those designed to influence economy-wide factors such as tax or patent measures, those designed to provide funding to small businesses for the innovation

Table 6
Demonstration of Usefulness of the Criteria with Existing Federal Activities

	<u>Initiatives to influence economy-wide factors</u>	<u>P.L. 96-354</u>	<u>Programs that provide management and technical assistance</u>
<u>NECESSARY CRITERIA</u>			
encourage exploitation of technological opportunity	P	0	X
ensure managerial and technical capacity of individual firms	0	0	X
ensure adequacy of financial and human resources throughout innovation process	P	P	X
promote innovation in technologies and industries in which small businesses can assemble requisite resources	0	0	X
<hr/>			
<u>IMPORTANT CRITERIA</u>			
stimulate creation and augmentation of technological opportunity	P	0	X
increase availability of financial and human resources	0	P	P
<hr/>			
<u>DESIRABLE CRITERION</u>			
address enough incentives and barriers to influence the balance between them positively	P	P	P

X = meets criterion 0 = does not meet criterion P = meets criterion partially or indirectly

process itself, and those designed to provide technical and management assistance directly to small businesses. In this section, we demonstrate the usefulness of the criteria established earlier in this chapter with three types of existing Federal efforts. Table 6 summarizes the use of the criteria.

Efforts to influence economy-wide factors

The 96th Congress passed two laws that can be expected to influence economy-wide factors--Public Law 96-517 (patents) and Public Law 96-354 (regulatory flexibility). Other efforts that might be expected to influence innovation through economy-wide factors, such as capital formation measures, were also passed by the 96th Congress, but only these two had as a specific objective the support of small innovative businesses.

Public Law 96-517 specified amendments to the patent and trademark law. Especially relevant to small-business innovation was the provision that small businesses may retain title to inventions created with support of Federal funds. This provision intends "to ensure that inventions made by nonprofit organizations and small business firms are used in a manner to promote free competition and enterprise . . ." (35 U.S.C. 200).

Public Law 96-354, the Regulatory Flexibility Act, amends title 5 of the United States Code to improve Federal rulemaking by creating procedures to analyze the availability of more flexible regulatory approaches for small entities. The amendment is based in part on the finding that "the failure to recognize differences in the scale and resources of regulated entities has in numerous instances adversely affected competition in the marketplace, discouraged innovation and restricted improvements in productivity . . ." (5 U.S.C. 601).

Neither the patent law revisions nor the regulatory flexibility measure meets in any substantial way the criteria for conditions necessary for small-business innovation. The regulatory flexibility measure is unlikely to meet any of the necessary criteria, with the possible exception of releasing for other purposes the human and financial resources that had been invested in regulatory compliance. The patent bill goes further than the regulatory measure toward meeting the necessary criteria. By retaining title to inventions, small businesses may be encouraged to exploit or augment technological opportunity embodied in an invention, and similarly the protection the patent provides from other businesses producing the innovation may be an incentive to commercialization. Also, the patent provisions may aid a small firm in generating resources to support development and commercialization of the invention.

However, these two measures do meet the desirable criterion by addressing enough factors to influence the incentives balance

in what is likely to be a positive direction. Patents are generally regarded as incentives to innovation, and reductions in regulatory burdens are commonly regarded as removing barriers. Both of these measures attempt to influence the economy-wide climate for innovation by increasing incentives (patents) and removing a barrier (regulation). While neither measure alone is likely to alter the incentives balance significantly in a positive direction, taken together or linked with other similar efforts both measures may begin to do so.

In summary, the two efforts to which we applied our criteria were intended to influence the economy-wide climate for innovation and might be expected to make that climate more positive for small businesses. But while a positive economy-wide climate is desirable, it is less important than other conditions for supporting the activities of small businesses as innovators. These efforts, however, do meet a few of the conditions that are necessary or important for supporting small businesses as innovators. Patent law revision may positively influence the exploitation and augmentation of technological opportunity, and it may also be an incentive to commercialization. Both measures may indirectly affect the availability of resources.

Programs that provide funding
or management and technical
assistance

Federal programs designed to directly support small businesses as innovators generally provide either funding for the innovation process itself or various types of technical and management assistance to small businesses. In either case, these programs are meant to support small businesses as a class, or some subset of all small businesses such as high-technology firms, and not individual firms *per se*. Examples of programs operated or funded by agencies in the Federal Government with the specific objective of providing funding or technical and management assistance to small innovative businesses are listed in table 7. Brief descriptions of these programs are presented in appendixes IV and V.

Funding programs

The four programs in table 7 that provide funding for the innovation process in individual small businesses are designed to operate similarly. Their objective is to support small businesses in research and development or in innovation. The Department of Energy programs focus on potential innovations in energy-related or appropriate technology areas. They provide to small businesses both funding for the innovation process and technical and management assistance. The Department of Defense program solicits research in defense-related areas. The National Science Foundation (NSF) program solicits research covering a wide range of topics and supports "applied research

Table 7

Examples of Federal Programs That Assist
Small Innovative Businesses

PROGRAMS THAT PROVIDE FUNDING
FOR THE INNOVATIVE PROCESS

--Department of Defense

Small Business Advanced Technology Program

--Department of Energy

Appropriate Technology Program

Energy-Related Inventions Program

--National Science Foundation

Small Business Innovation Research Program

PROGRAMS THAT PROVIDE TECHNICAL
AND MANAGEMENT ASSISTANCE

--Department of Commerce

Minority Business Development Agency
Technology Commercialization Program

--Small Business Administration-funded innovation centers

Commercial Credit Services Corporation

Golden Gate Energy Center

Montana Energy Research and Development Institute
Center for Innovation

proposals on important scientific or technical problems or opportunities." 1/

Each of these programs evaluates the managerial and technical capacity of sponsoring firms and the technical feasibility of the innovative activities proposed through proposal review

1/Topics include conservation of materials and resources; bio-sources of materials; genetic technology; advanced manufacturing processes; advanced chemical processes; industrial biological processes; microelectronics; communications and systems;

processes before contracts are awarded. The Energy-Related Inventions program does this through technical evaluation provided by the National Bureau of Standards. The three other programs treat technical aspects of proposals as criteria for selection during the competitive bidding. Each program provides "phased support," meaning that recipients of funds must successfully complete preliminary stages of the innovation process in order to qualify for further funding. For example, in the NSF program, awards for the first phase of research are based on the feasibility of the idea and the technical capabilities of the firm. Funding for the next phase, the principal research effort, is provided if the firm meets the objectives set by it for first phase results or if phase I results are very promising.

These four programs are consonant in design with all the criteria that are necessary in fostering conditions that support the activities of small businesses in innovation. The different phases of funding and support correspond with the three stages of the innovation process defined in chapter 1 of this report. Therefore, these programs assist small businesses throughout the innovation process, rather than just at one stage, as would be the case with programs that supported only R&D. The provisions in these programs for demonstration and planning for commercial application (the Energy programs) and for follow-on production contracts (the Defense program) encourage the practical application of the results of Federal support. The NSF program goes the furthest in this regard by encouraging a commitment for follow-on funding from a third party for commercialization of the innovation before NSF grants funds for the principal research effort (second phase funding).

Each of these programs meets one of the necessary criteria by ensuring the managerial and technical capacity of firms, because in each program proposals are judged on an organization's capabilities as well as on scientific merit. Finally, all the programs provide firms with financial resources to support their innovative activities.

Programs designed to provide funding meet the important criteria for conditions to support activities by small innovative businesses, in that they stimulate the creation or augmentation of technological opportunity. With regard to the desirable

computer science and engineering; robotics and controls; scientific and industrial measurements; radiation processing and control; light machinery and components; advanced automotive research; food process engineering; marine resources; mineral resources; environmental technology; tunneling, drilling, excavating, and dredging; earthquake engineering; science and technology aid to the handicapped; and appropriate technology. See Small Business Innovation Research Program Solicitation, National Science Foundation, April 1, 1981.

criterion, these programs individually are unlikely to have a positive influence on the incentives balance on a national scale, but they will affect the incentives balance within individual firms. Taken together these programs may, through a multiplier effect, make the economy-wide climate for innovation more positive, but the extent of this effect is difficult to predict.

Management and technical assistance programs

The four programs in table 7 that provide technical and management assistance are designed in a way that meets criteria that are necessary for conditions to support the activities of small businesses in innovation. The objective of each program includes the development and commercialization of innovations by small businesses. The Technology Commercialization Program under the Department of Commerce provides assistance to minority-owned businesses. The Golden Gate Energy Center under Small Business Administration (SBA) funding provides assistance specifically on energy-related ideas. The other two programs--the Montana Energy Research and Development Institute Center for Innovation and the Commercial Credit Services Corporation Innovation Center--provide assistance for ideas in many technical areas. Taken together, the three SBA programs constitute an experimental project, with limited funding, whose objective is to determine whether the centers do increase innovation substantially. (Results of their evaluation were imminent but not yet available at the time this report was printed.)

These four programs provide essentially the same services to client firms. 1/ These are:

- evaluating technical feasibility and applicability of technologies;
- identifying potential markets;
- giving management and financial assistance, including personnel management and selection, preparation of cash-flow statements, balance sheets, and income statements;
- providing comprehensive business planning to determine future events required for the successful commercial application of the idea or technology.

These programs are designed in a way that is consonant with the criteria that are necessary for conditions that support the

1/The Technology Commercialization Program funds a number of centers throughout the country, each of which provides essentially these same services. These centers emphasize a brokerage function, which the three SBA-funded centers do not.

activities of small businesses in innovation. The centers help client businesses develop a business plan that recognizes each stage of the innovation process from invention (technical feasibility analysis) through development (R&D planning and engineering assistance) to commercialization (market assessment). Imperative in each of the center's services is a view toward commercialization of the innovation.

Client firms are assessed for their possession of the requisite technical and managerial skills to support the innovation, and if either skill is missing the centers provide or help firms locate appropriate assistance. The planning process undertaken in each center helps ensure that the firm is embarking in a technological area or industry in which the firm can assemble the requisite resources to support innovation. The planning process also ensures that the human and financial resources required are accessible to the firm.

The centers are designed in a way that is unlikely to influence the creation or augmentation of technological opportunity (an important criterion), but they do encourage exploitation of existing technological opportunity. Like programs that provide funding for the innovation process, the individual centers are unlikely to effect economy-wide changes in the incentives balance (a desirable condition) but will do so for individual firms.

In summary, programs to provide funding or technical and management assistance are designed in a way that addresses the conditions necessary to support small businesses as innovators. These programs focus on improving the climate and incentive for innovation within individual small businesses; a positive climate is necessary if innovation is to occur. The funding programs are also designed in a way that is likely to stimulate the creation or augmentation of technological opportunity, which is important for innovation. While these programs individually cannot be expected to improve the economy-wide incentives balance (a desirable criterion), a positive incentives balance within individual firms is likely to be created. The aggregate effect of giving individual firms funding or management and technical assistance may positively influence the economy-wide climate for innovation. Predicting the extent of this, however, would be quite difficult.

CHAPTER 5

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Today's concern about the capability of small businesses to innovate is prompted by a larger concern about a perceived decline in U.S. industrial innovation and the belief that small businesses are vital to innovation in this country. Small businesses contribute significantly to innovation, but the relevant literature does not allow us to determine the extent of the contributions small businesses make. Instead, it informs us of the factors that influence the environment within which small businesses can innovate and the different ways they are most likely to innovate within their environment. In this report, we have shown what influences the environment within which small businesses in the manufacturing sector innovate, and we have shown how small businesses act as innovators in that environment. We have also shown which of their environmental factors are sensitive to Federal policy actions, particularly those that are reflected in criteria for Federal initiatives designed to support small businesses as innovators.

THE ENVIRONMENT FOR INNOVATION FOR SMALL BUSINESSES

We demonstrated in chapter 2 that small businesses innovate in the broad context of the society and industry in which they operate. The context is determined by the relationships among economy-wide, industry-specific, and individual-firm factors. The climates for innovation produced by each of these three groups of factors exert a particular influence on the overall environment for innovation that either supports or inhibits innovative activities.

The economy-wide climate for innovation sets the atmosphere within which all industries and firms operate. Similarly, the climate for innovation within an industry affects all firms operating in that industry. The climate for innovation within a firm, then, results from (1) the combination of factors that characterize that particular firm, (2) the climate in the industry in which the firm operates, and (3) the broader economy-wide climate that affects both the industry and the firm.

A positive economy-wide climate for innovation increases the probability that innovation will occur, but it is not sufficient to stimulate active innovation. The primary effect of a negative economy-wide climate for innovation is to inhibit innovation in ways that are likely to prevent wide-spread, active innovation across all industries. A negative economy-wide climate may be so pervasive that it may alter the climates in both the industry and the firm.

Firms in an industry with a positive climate are more likely to innovate than firms that are operating within a negative industry climate. A positive industry climate is not sufficient to make innovation happen, but it is likely to stimulate it. A positive climate within an industry is likely to overcome a negative economy-wide climate for innovation and result in innovative activity by a greater number of firms within that industry, even though firms in other industries may have abandoned innovative activities because of a negative industry climate. A positive climate for innovation within an industry will not, however, affect firms that do not already have some propensity to innovate. It will make it easier for firms with a propensity to innovate, and it may stimulate the formation of new firms. A negative climate within an industry, however, is likely to counteract both positive economy-wide and individual-firm climates and, hence, essentially preclude innovation in that industry.

If there is a positive climate for innovation within a firm and the firm perceives the economy-wide and industry climates as at least neutral or somewhat conducive to innovation, then it is possible that a given firm will initiate the innovation process. This is not to say that innovation will occur. It is simply to say that innovation is more likely than in firms whose climate for innovation is negative. Innovation will almost certainly be precluded in firms without a positive climate for innovation.

THE INNOVATIVE ACTIVITIES OF SMALL BUSINESSES VARY BY INDUSTRY

In chapter 3, we showed that the way small businesses participate in innovation is determined in large measure by the structure of their industry and other industry-specific variables. The actions of small businesses in innovation are related to the structure of the particular industry in which they operate and can be one of two types. Small businesses are either primary contributors or complementary contributors to innovation.

A small business is most likely to be a primary contributor in atomistic industries, in which most firms are small. In this circumstance, small businesses are likely to account for the majority of all innovative activity in a given industry. Small businesses are more likely to be complementary contributors in more concentrated industries, whether mixed, oligopolistic, or monopolistic. In these cases, small businesses tend to perform specialized innovative functions and develop products that are used by other, usually larger, firms in their or other industries.

CONDITIONS CONDUCIVE TO INNOVATION

In chapter 4, we drew upon our analysis of the factors that influence the environment for innovation and the activities of small businesses within that environment to isolate the conditions conducive to innovation's flourishing. On our scale of criteria,

it is necessary that individual firms have a positive climate for innovation because the decision to innovate is made within individual firms. In addition to having a positive climate, a firm should also be capable of producing the innovation at a cost competitive with substitute goods and be able to assemble adequate resources to support the innovation process. If the innovation process is to be successfully completed by a firm, the result of the firm's innovative activities must be introduced into commercial use as either an intermediate or a final output.

It is important and quite helpful for the industry climate within which the small firm operates to be positive, although this is not as necessary as that the firm climate be positive. And it is desirable, but not as important, for the economy-wide climate for innovation to be positive.

These necessary, important, and desirable conditions for the activity of small businesses in innovation are influenced by the economy-wide, industry-specific, and individual-firm factors we discussed in chapter 2. Only some of the factors that influence the economy-wide and industry climates are readily amenable to Federal policy influence, however. Most of the factors within an individual firm--size, structure, strategy, maturity--are not as directly subject to policy manipulation as are availability of resources and technological opportunity, which can be directly influenced through policy measures. A firm's climate is also affected by changes in the economy and the industry. Within an industry, three factors--the availability of capital and resources, technological opportunity, and the balance between demand and supply--are sensitive to policy manipulation. Of the ten economy-wide factors discussed in chapter 2, only two--incentives and barriers--are readily amenable to policy influence.

CRITERIA FOR FEDERAL INITIATIVES TO SUPPORT SMALL-BUSINESS INNOVATION

From our analysis of the conditions that are necessary, that are important, and that are desirable for small businesses to be active in innovation, we developed criteria for judging the efficacy of Federal initiatives designed to support small businesses in innovation.

The following questions reflect the conditions that are necessary if Federal initiatives are to support the activities of small businesses as innovators:

--Does the initiative encourage exploitation of technological opportunity?

--Does the initiative provide mechanisms to ensure that the firm sponsoring the innovation has the managerial and technical capacity to support the innovation at each stage of the process (invention, development, and commercialization)?

- Does the initiative provide mechanisms to ensure that financial and human resources adequate to support innovation at each stage of the process are available to the firm?
- Does the initiative encourage innovation in technologies and industries in which small businesses can be expected to assemble necessary resources to support each stage of the innovation process?

The following questions reflect the conditions that are important if Federal initiatives are to support small businesses as innovators by influencing the climates for innovation within industries:

- Is the initiative designed to stimulate the creation of technological opportunity or augment existing technological opportunity?
- Does the initiative provide mechanisms to ensure the availability of financial and human resources?

The following question reflects the conditions that are desirable if Federal initiatives are to support small businesses as innovators by influencing the economy-wide climate for innovation:

- Does the initiative, alone or in combination with other initiatives, address enough incentives and barriers to alter the balance between them in a positive way?

SOME FEDERAL ACTIVITY DESIGNS MEET NECESSARY CRITERIA

Federal efforts to support the activities of small businesses as innovators are generally of two types--those designed to influence economy-wide factors and those designed to provide funding or technical and management assistance directly to small businesses. We demonstrate the use of our criteria with two Federal efforts designed to influence economy-wide factors--Public Law 96-517, amendments to the patent and trademark laws, and Public Law 96-354, to promote regulatory flexibility. These Federal efforts might be expected to make the economy-wide climate for innovation more positive for small businesses by altering the incentives balance in a positive direction. For example, certain economy-wide factors such as patent rights can have a positive effect on individual small businesses. However, while a positive economy-wide climate is desirable, it is neither a necessary nor a sufficient condition to support the activities of small businesses as innovators.

We also demonstrate the use of our criteria with programs designed to provide funding or those designed to provide management and technical assistance directly to small innovative businesses.

An example of the former is the National Science Foundation's Small Business Innovation Research program, and examples of the latter are the centers sponsored through the Technology Commercialization Program of the Minority Business Development Agency in the Department of Commerce. These programs are designed in a way that matches the criteria that are necessary for conditions that support the activities of small businesses as innovators. While programs of this type might be expected to improve the incentives balance within individual firms, individually the programs are unlikely to have any significant influence on the economy-wide incentives balance.

CONCLUSIONS

Our understanding of the factors that influence the environment for innovation, the activities of small businesses within that environment, and the conditions necessary for small businesses to be active as innovators, enables us to conclude that

- Small businesses act differently as innovators depending on the characteristics of the industry of which they are a part. Each possesses special strengths and makes particular contributions to innovation in this country.
- How likely it is that small businesses will innovate is influenced by a complex set of economy-wide, industry-specific, and firm factors that combine to form an environment for innovation.
- Only some of the factors that influence the environment for innovation are readily amenable to policy influence. Individual incentives and barriers, technological opportunity, availability of capital and other resources, and balance between demand and supply are the factors that are most amenable to policy action.
- The environment for innovation is common for all potential innovators. Measures intended to affect one category of innovator, such as small businesses, will also affect other categories of innovators (medium-sized or large businesses), although the effect of these measures may be quite different on each category.
- Use of the criteria with Federal efforts to influence economy-wide factors, such as tax and patent policy, indicates that those efforts meet desirable but not necessary criteria for conditions to support the activities of small businesses as innovators.

--Use of the criteria with Federal programs that provide funding or technical and management assistance directly to small firms indicates that those programs meet the criteria that are necessary for conditions to support the activities of small businesses as innovators.

FURTHER IMPORTANT RESEARCH

The information in this report can help the Congress by beginning to answer several important questions, but many areas still require further research. Particularly useful would be research that would refine and test our understanding of the effect of the numerous factors on the environment within which innovation occurs and on the activities of small businesses within that environment. Specifically, questions for research that could build upon the analysis presented in this report should include:

- What is the relationship between the degree of concentration in an industry and that industry's state and rate of change of technology?
- What is the relationship between the degree of concentration in an industry and the activities of small businesses in innovation in that industry?
- What are the similarities and differences between small high-technology-producing firms operating on their own in private markets as contrasted with those depending to some degree on Federal R&D contracts? What has been the relative incidence of success in innovation of the firms operating in private markets compared to firms competing for Federal R&D contracts? 1/

Other research questions that were beyond the scope of this report include:

- Are small businesses at any particular disadvantage relative to other potential innovators in their efforts to innovate?
- What activities do other innovators--large and medium-sized businesses, university and government

1/Research proposals for this set of questions were solicited by a "Dear Colleague" letter released in September 1980 by the National Science Foundation's Industry/University Cooperative Research Projects program before the formation of the Industrial Science and Technological Innovation division was formed (in March 1981); the program is now a part of ISTI.

laboratories, or other institutions--perform in the innovation process? How do those activities relate to the activities of small businesses?

--Are the efforts of small businesses or other potential innovators being inhibited by specific Federal policies?

AGENCY COMMENTS
AND OUR RESPONSE

The National Science Foundation (NSF), the Small Business Administration (SBA), and the Department of Commerce (DOC) reviewed and commented on a draft of this report. All three agencies concur that the report is an important contribution to what is known about small businesses and innovation. While NSF finds the draft study "an interesting presentation on the contribution of small businesses to the process of innovation in the private sector," DOC comments that our approach is "systematic, unbiased, and more comprehensive than existing studies." DOC states further that the framework presented in the report "should prove very useful and valuable" for policy analysis and decisionmaking. We reprint their letters in appendixes VI through VIII along with our responses to their comments on specific points. We discuss their more significant comments below.

NSF and SBA comment on the related matters of the importance of the entrepreneur and the influence of the profit motive on the likelihood that small businesses will innovate. Specifically, NSF thinks that the report should reflect more than it does the importance of the entrepreneurial role in initiating and developing new businesses and should also "recognize more the importance of the key individual or individuals in implementing the various components of the innovation process from idea generation to later stage financing of growing businesses." NSF states further that the report implies that the resources and stimulation necessary for business development are essentially mechanical or structural in nature, the report identifying no personal attributes or profit motive with the innovation process.

SBA expresses concern that the report "does not give adequate emphasis to the extent to which the profit motive creates the incentive for the innovative effort" of firms. In addition, SBA states that "it would be fair to challenge" our comment (now on page 16 of the report) that invention is "least likely to be constrained by profitability considerations."

We agree with NSF that the presence of an individual or entrepreneur is important to the innovation process in small businesses. In the draft copy that NSF reviewed, we in fact recognized this explicitly in table 1 (now on p. 9) and in a summary statement about the firm model (now on p. 21). In that draft, we also made the importance of the entrepreneur explicit where we discussed the special case of new small businesses and emerging industries

(see pp. 27-28). Further, we stated in the draft that among the conditions that are necessary to support small-business innovation are "the technical, managerial, and financial resources necessary to exploit the technological opportunity" (see table 5). Our definition of technical and managerial resources includes people --people who have necessary technical expertise and entrepreneurs. We have not changed these passages, and they remain as they were in the draft. We have, however, responded to NSF's comment about the role of the entrepreneur by amplifying the discussion where appropriate.

Similarly, we agree with SBA that the profit motive is an important incentive and stimulus for innovation. The importance of the profit motive to innovation is implicit in many of the factors we discuss throughout the report, but it is noted specifically where we discuss the climate for the innovation within individual industries. Indeed, SBA quotes the section of the report in which we state our position on this issue: "implicit in the availability of capital and resources is the concept of profitability. Innovative projects will not be undertaken if they are not expected to yield the return on investment required by the firms initiating the projects" (see p. 16). In addition to retaining that statement, we have, in response to SBA's comment, added emphasis to the profit motive as an incentive to innovation where appropriate throughout the report.

With regard to SBA's concern about our statement that invention is least likely to be constrained by profitability considerations, we believe that SBA is overlooking the distinction we make between invention, development, and commercialization. In making the statement, we were referring to our definition of innovation--a process that "begins with the genesis of a technically feasible idea (invention), proceeds with the refinement of the idea (development), and results in the introduction and initial use of new products and processes into the marketplace (commercialization)" (p. 7). Using this definition, we can distinguish the activities, personnel, resources, and results of each stage of the innovation process. To respond to SBA's concern, we have reworded the statement so that it now reads: "Of the three stages of the innovation process, invention is the least likely to be constrained by profitability considerations" (p. 16).

We agree with SBA that the profit motive is important, but we disagree with the degree of emphasis SBA assigns to it. While the profit motive is in fact an important incentive to undertaking innovation activities, it cannot be emphasized to the exclusion of other factors. Profit alone is not sufficient to stimulate innovation. Other factors--those we discuss in chapter 2--have an important influence on whether a firm will be able to pursue innovative activities and realize profits from them. Further, we do not agree with SBA's statement that "any legislative activity or any administrative mandate should be addressed to this specific point"--that is, the profit motive. Government actions

to support innovation should attempt to address all factors--including the profit motive--that are important in stimulating innovation.

In a separate concern, SBA requests that we remove references in chapter 4 to the SBA-funded innovation centers. SBA emphasizes that the centers are experimental and that the centers have not been evaluated nor has their effectiveness. We appreciate SBA's concern that neither positive nor negative comments be made about Federal projects that have not yet been evaluated. However, we used these three centers--and other programs--as examples to illustrate the usefulness of the criteria we developed for judging the efficacy of Federal initiatives. Our purpose was not to evaluate the programs we cited, and we have made this point explicit where appropriate in the report.

DOC's two major points are that the models we present in chapter 2 "raise more questions than they help to answer" and that an alternative approach in viewing the complex relationships depicted in the models might have been to use case studies. We agree that case studies would amplify the information in the models. However, we believe that these models are a first step in identifying factors important to innovation and the relationships among those factors. Subsequent case studies could help to clarify relationships and test hypotheses. We also agree that the models do, in fact, raise a number of questions about the factors that influence innovation and the interrelationships among those factors. However, we have presented our models as collections of hypotheses, and therefore we expect them to raise questions. In fact, we identified several important research questions during work on this report. These questions were present in the draft and are set forth in the section beginning on page 46 of this report.

RECOMMENDATION TO THE CONGRESS

The Congress has responded actively to the perceived decline in innovation in this country by making numerous efforts to stimulate innovation in general and to support the activities of small businesses in particular. At the present time, the Congress has under consideration a number of initiatives that would establish small-business innovation research programs in Federal agencies with research and development budgets in excess of \$100 million, amend the Internal Revenue Code of 1954 to allow reduction in capital gains taxes for qualified small businesses, extend capital loss carryover, provide for research and experimental expenditure reserves, and serve a number of other purposes. 1/

1/The initiatives are H.R. 11, an omnibus bill entitled the Small Business Innovation Act of 1981, and H.R. 3091 and S. 881, identical bills amending the Small Business Act to establish small-business innovation programs in Federal agencies.

We recommend that in its deliberations on these and future small-business innovation initiatives, the Congress use the criteria presented in this report to assess the degree to which proposed initiatives would enhance the conditions that foster innovation by small businesses.

ANNOTATED BIBLIOGRAPHY OF STUDIES
OF SOURCES OF INVENTION
AND INNOVATION

CHARPIE, Robert, ed. Technological Innovation: Its Environment and Management. U.S. Department of Commerce Panel on Invention and Innovation. Washington, D.C.: U.S. Government Printing Office, 1967.

Commonly known as the Charpie Report. The authors were an ad hoc panel on invention and innovation that had been asked to explore the opportunities for improving the climate for technological change. The report was based for the most part on the authors' experience with industrial innovation; they did not collect original data.

ENOS, John L., ed. "Inventions and Innovation in the Petroleum Refining Industry." In The Rate and Direction of Inventive Activity. Princeton: Princeton University Press, 1962.

A study of a sample of 7 major inventions in refining and cracking petroleum for the National Bureau of Economic Research.

FREEMAN, Christopher. "The Role of Small Firms in Innovation in the United Kingdom Since 1945." Occasional paper for Science Policy Research Center, March 1978, in London, England.

A survey of the role of 1,200 firms in British innovation. Freeman reported the findings of this study in his more commonly known work, The Economics of Industrial Innovation (Baltimore: Penguin Books, 1974).

GELLMAN RESEARCH ASSOCIATES. "Indicators of International Trends in Technological Innovation." In Science Indicators. Washington, D.C.: National Science Foundation, 1976.

Commonly known as the Gellman Report. It explores international innovation activity, based on examination of 500 innovations marketed between 1953 and 1976.

HAMBERG, Daniel. "Invention in the Industrial Research Laboratory." The Journal of Political Economy, 71 (1963), 95-115.

A study of 45 major inventions from 1946 to 1955 and of 13 innovations in the American steel industry from 1940 to 1955.

APPENDIX I

APPENDIX I

JEWKES, John, D. Sawyers, and R. Stillerman. The Sources of Invention, 2nd ed. New York: W. W. Norton, 1969.

An extensive examination of the sources of invention for 61 selected innovations.

MUELLER, Willard F., et al. Market Structure and Technological Performance in the Food Manufacturing Industry. Madison: University of Wisconsin, 1979.

A study of the relationships among inventive activity, industrial structure, and firm characteristics within the food industry. The study reviewed patents issued in six related industries from 1969 to 1977 and the recipients of the Patnam Food Awards.

PECK, Merton J. "Inventions in the Post-War American Aluminum Industry." In The Rate and Direction of Inventive Activity: Economic and Social Factors. National Bureau of Economic Research. Princeton: Princeton University Press, 1962.

A study of 149 inventions in aluminum welding, fabricating techniques, and finishing.

RABINOW, Jacob. Small Firms and Federal Research and Development. Ad Hoc Interagency Panel, Office of Federal Procurement Policy. Washington, D.C.: Office of Management and Budget, 1972.

A synthesis of approximately 75 documents to determine whether small firms share appropriately in Federal research and development procurement.

MEASUREMENT AND METHODOLOGICAL PROBLEMS
IN THE INNOVATION LITERATURE

Research on innovation and its sources suffers from measurement and methodological problems that make interpretation of research findings difficult and generalization from the findings inconclusive. In this appendix we briefly discuss these problems.

MEASUREMENT PROBLEMS

One or more of four indicators is generally used to measure innovation--scientists and engineers employed, R&D expenditures, patents issued, and counts of innovations. There are questions about the validity of each.

Scientists and engineers employed

This measure is biased toward labor-intensive R&D activities and it covers only employees formally or exclusively employed to conduct R&D activities. At best, this measure is only a partial indicator of potential to innovate.

R&D expenditures

Research and development may or may not result in the introduction of a new product or process into commercial use. Without commercial application, innovation does not occur, because the innovation process remains incomplete. Most small firms perform little or no specialized R&D at all, and R&D activities are heavily concentrated in large firms. In fact, Freeman found that less than 5 percent of small firms (those with fewer than 200 employees) perform R&D. 1/

Further, small firms tend not to distinguish R&D from other similar activities and hence do not aggregate R&D expenditures. This, together with the fact that R&D in large firms tends to be long term and expensive, greatly skews ratios such as innovations per R&D dollar in favor of small firms. Measures of R&D are likely to indicate the level of activity of organized, goal-directed development being undertaken by larger organizations, but they are not valid measures of the output of innovation from businesses, whether large or small.

Patents issued

The number of patents issued is a measure of inventive activity, not innovative output. The distinction is important.

1/Christopher Freeman, The Economics of Industrial Innovation
(Baltimore, Md.: Penguin Books, 1974).

Invention is only the first of many steps. It is the creation of a technically sound idea. A patent simply protects that idea from being used commercially by others. Moreover, that a patent has been issued does not indicate the likelihood that a patented invention will be put into commercial use. Therefore, patents can serve only as indicators of inventive activity. A given innovation may or may not be patented.

Patent statistics are confused by certain industries' propensity to patent. For example, Freeman found that firms in the defense industry are less likely to patent than firms in the chemical industry, which are quite likely to do so.^{1/} In the United States in particular, patent statistics may be skewed by the long time lags in processing patent applications and by the fact that many patents are reversed in courts of law after challenges from other holders of patents.

Counts of innovations

This measure is the only one that attempts to measure innovative activity directly, but its validity can also be challenged. Studies using counts of innovation are generally based on innovations introduced into the marketplace over long periods of time. They do not weight statistics given changing economic conditions or business demography. Often the innovations that are studied are specific to a particular industry and therefore are not appropriate to use in making assertions about the possibility of similar circumstances in other industries. Finally, there is serious disagreement about what constitutes an innovation. Even panels of experts often disagree about what "innovations" occurred during a given period in history.

METHODOLOGICAL PROBLEMS

Methodological problems include variation in the way small businesses are defined, problems with the size and methods of selecting samples of innovations, studies specific to only one industry, and variation in the time spans the studies cover.

Defining small business

There is no generally agreed upon definition of small business. However, commonly used measures include number of employees, total sales, or total assets. Given that there is neither a linear nor a causal relationship among these three measures, using different measures yields different sets of small businesses. The definition of small business differs from study to study in the list in appendix I. Size thresholds ranged from 100 to 1,000 employees. Despite the significant variations, these studies are generally quoted as if to imply that

^{1/}Ibid.

their definitions of "small" are the same. Conclusions about 100-employee firms are unlikely to hold for 1,000-employee firms.

Sample size and selection

None of the studies listed in appendix I is based on a statistically valid sample. The samples selected for these studies were based on counts of innovations, the problems of which we discussed previously. There is a serious question about whether it is even possible to draw a statistically valid sample of innovations. In fact, most of the authors of the studies listed in appendix I specifically caution against generalizing from their study data to other situations.

The size of the samples drawn for the studies listed in appendix I varies greatly. Of the seven studies that collected original data, only three have samples larger than 100. The four others have samples ranging from 7 to 61 innovations.

Industry base

Of the seven studies in appendix I that collected data, four were industry-specific in their inquiry. Hamberg examined the character of inventions likely to issue from the research laboratories of large industrial corporations. Peck, Enos, and Hamberg in another study examined the aluminum, petroleum, and steel industries. Using these studies of highly concentrated industries to understand the activities of small businesses in innovation raises serious questions of applicability. The studies are nevertheless quite useful in beginning to understand the individual factors and characteristics that influence a firm's ability to innovate in a given industry.

Time span of samples

Samples of innovations are often drawn from quite long time periods. For example, the 61 inventions Jewkes examined spanned a 55-year period. Others were comparatively short; Hamberg studied 45 inventions arising during a 9-year period. The social, economic, and technological environments prevalent during the time these samples were drawn are quite different from those today. While it is appropriate to argue that the basic nature of the process of innovation does not change with drastically different time periods, many other changes do occur. The demography of the business community is quite different today from what it was in the period 1900-55, from which Jewkes drew his sample, or 1946-55, from which Hamberg drew his work. The economic constraints on a firm's innovative initiative also differ. Finally, the social and technological contexts in which innovation takes place today--and, hence, the kind of innovation that occurs--vary greatly. Such differences provide reason for using extreme caution in generalizing from these data to today's innovators.

SELECTED BIBLIOGRAPHY

This bibliography is a sampling of sources for beginning inquiries into specific aspects of innovation and associated topics. It represents the diversity of the literature upon which we based this report.

ABERNATHY, W. J. The Productivity Dilemma: Roadblock to Innovation in the Automobile Industry. Final report, Harvard University, NSF Grant No. PRA-7420571, April 1976. Baltimore: The Johns Hopkins University Press, 1978.

----- and Balaji S. Chakrovarthy. "Government Intervention and Innovation in Industry: A Policy Framework [for] Government Policy to Encourage Innovation." Paper presented at the American Association for the Advancement of Science Meeting, February 15, 1978, in Washington, D.C.

----- and J. M. Utterback. "Patterns of Industrial Innovation." Technology Review, 80 (1978), 40-47.

ADAMS, Walter. The Structure of American Industry. New York: Macmillan, 1977.

ALLEN, J. A. Studies in Innovation in the Steel and Chemical Industries. New York: Augustus M. Kelley, 1968.

ALLEN, Julius W. "The Concept of a Sick Industry." Library of Congress, Congressional Research Service 78-151E, July 1978.

ARTHUR LITTLE, INC., and Industrial Research Institute. Barriers to Innovation in Industry. Final report, NSF Contract Nos. C725 and C748, September 1973.

ASHER, Herbert B. Causal Modeling. Beverly Hills, Calif.: Sage Publications, 1976.

ASHFORD, Nicholas. "The Implications of Health, Safety, and Environmental Regulations for Technological Change." Cambridge: MIT Center for Policy Alternatives, 1979.

BEAN, Alden S., et al. "The Venture Capital Market and Technological Innovation." In Office of National R&D Assessment, Research Policy. Vol. 4. Washington, D.C.: National Science Foundation, 1975.

BECKER, Selwyn W., and Thomas L. Wisler. "The Innovative Organization: A Selective Review of Current Theory and Research." The Journal of Business, 40 (1967), 462-69.

APPENDIX III

APPENDIX III

BIRCH, D. "The Job Generation Process." Unpublished manuscript. Cambridge: MIT Program on Neighborhood and Regional Change, 1979.

BOYLAN, M. "Reported Economic Effects of Technological Changes." In Research, Technological Change, and Economic Analysis, edited by B. Gold. Lexington, Mass.: Lexington Books, 1977.

----- "The Sources of Technological Innovations." In Research, Technological Change, and Economic Analysis, edited by B. Gold. Lexington, Mass.: Lexington Books, 1977.

BRUNO, Albert, and Tyzoon Tyebjee. "The Environment for Entrepreneurship." In The Mini-Encyclopedia of Entrepreneurship, edited by D. Sexton et al. Englewood Cliffs, N.J.: Prentice-Hall, forthcoming.

CAPRON, William E., ed. Technological Change in Regulated Industries. Washington, D.C.: The Brookings Institution, 1971.

CHAKRABARTI, Alok K., et al. A Review of Critical Factors Affecting Federal Innovation and Some Policy Implications. National Center for Productivity and Quality of Working Life. Washington, D.C.: National Technical Information Service, 1978.

CHARLES RIVER ASSOCIATES. Innovation, Competition, and Government Policy: A Framework for Analysis. National Bureau of Standards, Experimental Technology Incentives Program. Washington, D.C.: U.S. Department of Commerce, 1980.

----- The Impact on Small Business Concerns of Government Regulations That Force Technological Change. Final report, U.S. Department of Commerce, National Bureau of Standards, Small Business Administration and Experimental Technology Incentives Program SBA 2098-PRA-75, September 1977.

----- An Analysis of Venture Capital Market Imperfections. Final report, U.S. Department of Commerce, National Bureau of Standards, Experimental Technology Incentives Program, 1976.

CHARPIE, Robert A., ed. Technological Innovation: Its Environment and Management. U.S. Department of Commerce Panel on Invention and Innovation. Washington, D.C.: U.S. Government Printing Office, 1967.

COLTON, Robert M. "Technological Innovation Through Entrepreneurship." Engineering Education, 68 (1978), 193-96.

COOPER, Arnold. "Entrepreneurship--Small Business Interface." In The Mini-Encyclopedia of Entrepreneurship, edited by

APPENDIX III

D. Sexton et al. Englewood Cliffs, N.J.: Prentice-Hall, forthcoming.

CRANDALL, David P. "An Executive Director's Struggle to Actualize His Commitment to Collaboration." The Journal of Applied Behavioral Science, 13 (1977), 340-51.

DOWNS, George W., and Laurence Mohr. "Conceptual Issues in the Study of Innovation." Administrative Science Quarterly, 21 (1976), 700-14.

ENOS, John L. "Inventions and Innovation in the Petroleum Refining Industry." In Rate and Direction of Inventive Activity. Princeton: Princeton University Press, 1962.

FREEMAN, Christopher. "Economics of Research and Development." In Science, Technology, and Society: A Cross-Disciplinary Perspective, edited by Ina Spiegel-Rosing and Derek de Salla Price. Beverly Hills, Calif.: Sage Publications, 1977.

-----. The Economics of Industrial Innovation. Baltimore: Penguin Books, 1974.

GELLMAN RESEARCH ASSOCIATES. "Indicators of International Trends in Technological Innovation." In Science Indicators. Washington, D.C.: National Science Foundation, 1976.

GOLD, B. "The Decision Framework in Generating Major Technological Innovations: Some Unfashionable Hypotheses." In Analyses and Prevision. Paris: Organization for Economic Cooperation and Development, 1967.

Government Competition: A Threat to Small Business. Report of the SBA Advocacy Task Group on Government Competition with Small Business. Washington, D.C.: Small Business Administration, 1980.

GRABOWSKI, Henry G., and John M. Vernon. The Impact of Regulation on Industrial Innovation. Washington, D.C.: U.S. Government Printing Office, 1979.

GRAD, Marcia, and Louis Cicchinelli. "Innovation Center and Technical Assistance to Business Study." Report, Michigan Department of Commerce, Office of Michigan's Changing Economy Project, Contract No. 77-8, July 1977.

GRETHER, David M. "Market Structure and R&D." Claremont: California Institute of Technology, 1974.

HAMBERG, Daniel. "Invention in the Industrial Research Laboratory." The Journal of Political Economy, 71 (1963), 95-115.

HILL, C. T. "Technological Innovation: Agent of Growth and Change." Cambridge: MIT Center for Political Alternatives, 1978.

APPENDIX III

APPENDIX III

HILL, Christopher, and James M. Utterback. Technological Innovation for a Dynamic Economy. Elmsford, N.Y.: Pergamon Press, 1979.

HOROWITZ, Paul. "Direct Government Funding of Research and Development: Intended and Unintended Effects on Industrial Innovation." Cambridge: MIT Center for Policy Alternatives, 1979.

"Innovation in Small and Medium Firms Draft Repertory of Government Policies." Paris: Organization for Economic Cooperation and Development, February 1980.

"Innovation in Small and Medium Firms Preliminary Draft of the Synthesis Report." Paris: Organization for Economic Cooperation and Development, September 1980.

JEWKES, J., D. Sawyers, and R. Stillerman. The Sources of Invention, 2nd ed. New York: W. W. Norton, 1969.

JOHNSON, Jimmy D., ed. Survival and Growth of the Small R&D Firm. Proceedings of the First National NSF, SBA, and DOC Conference, September 1972, at American University, Washington, D.C.

KAMIEN, Morton I., and Nancy L. Schwartz. "Market Structures and Innovation: A Survey." Journal of Economic Literature, 13 (1975), 1-37.

KAPLAN, R. S. "Tax Policies of U.S. and Foreign Nations in Support of R&D and Innovation." In Tax Policies for R&D and Technological Innovation. Final report, Carnegie-Mellon University, NSF Grant No. RDA-7421227, September 1975.

KELLY, P., and M. Kranzberg. Technological Innovation: A Critical Review of Current Knowledge. 4 vols. NSF Grant No. RDA-7307230, February 1975.

KIMBERLY, John R. "Organizational Size and the Structuralist Perspective: A Review, Critique, and Proposal." Administrative Science Quarterly, 21 (1976), 571-97.

KLEIN, Burton H. "The Slowdown in Productivity Advances: A Dynamic Explanation." Cambridge: MIT Center for Policy Alternatives, 1979.

MACHLUP, Fritz. The Production and Distribution of Knowledge in the United States. Princeton: Princeton University Press, 1962.

MANSFIELD, Edwin. "Research and Development, Productivity Change, and Public Policy." In Preliminary Papers for a Colloquium on the Relationships Between R&D and Economic Growth/Productivity. Washington, D.C.: National Science Foundation, 1977.

APPENDIX III

MANSFIELD, Edwin. Industrial Research and Technological Innovation: An Econometric Analysis. Cowles Foundation for Research in Economics. New York: W. W. Norton, 1968.

----- et al. The Production and Application of New Industrial Technology. New York: W. W. Norton, 1977.

----- et al. Research and Innovation in the Modern Corporation. New York: W. W. Norton, 1972.

MOGEE, Mary. "The Process of Technological Innovation in Industry: A State-of-Knowledge Review for Congress." Unpublished manuscript. Library of Congress, Congressional Research Service, 1978.

MOHR, L. B. "Determinants of Innovation in Organizations." In Organizational and Managerial Innovation, edited by L. Rowe and W. Boise. Pacific Palisades, Calif.: Goodyear Publishing Co., 1973.

MYERS, Sumner, and Donald Marquis. Successful Industrial Innovations. MIT Sloan School of Management. Washington, D.C.: Institute of Public Administration, 1969.

MUELLER, Willard F., et al. "Market Structure and Technological Performance in the Food Manufacturing Industry." Report, NSF Grant No. Apr-76-03789, September 1979.

NATIONAL SCIENCE FOUNDATION. "Current Problems Facing Small R&D Firms." Report for Directorate for Scientific, Technological, and International Affairs, Division of Science Resources Studies, Contract No. SRS7925337, December 1979.

NELSON, R., J. Peck, and E. Kalachek. Technology, Economic Growth, and Public Policy. Washington, D.C.: The Brookings Institution, 1976.

NELSON, R. R., and S. G. Winter. "In Search of a Useful Theory of Innovation." In Office of National R&D Assessment, Research Policy. Vol. 6. Washington, D.C.: National Science Foundation, 1977.

NELSON, Richard. "The Role of Industrial Innovation in the United States Economy." Paper prepared for presentation at a forum organized by the Congressional Research Service, June 18, 1980, in Washington, D.C.

PAVITT, Keith. "Technical Innovation and Industrial Development." Futures, 11 (1979), 458-70.

----- and S. Wald. The Conditions for Success in Technological Innovations. Paris: Organization of Economic Cooperation and Development, 1971.

APPENDIX III

APPENDIX III

PECHMAN, Joseph A. Federal Tax Policy. Washington, D.C.: The Brookings Institution, 1977.

PECK, Merton J. "Inventions in the Post-War American Aluminum Industry." In The Rate and Direction of Inventive Activity. National Bureau of Economic Research. Princeton: Princeton University Press, 1962.

RABINOW, Jacob. Small Firms and Federal Research and Development. Ad Hoc Interagency Panel, Office of Federal Procurement Policy. Washington, D.C.: Office of Management and Budget, 1977.

RADNOR, M., I. Feller, and E. Rogers, eds. The Diffusion of Innovations: An Assessment. Final report, Northwestern University, NSF Grant No. PRA-7680388, 1978.

----- et al. "The R&D Management Literature and Innovation Diffusion Research." In The Diffusion of Innovations: An Assessment, edited by M. Radnor, I. Feller, and E. Rogers. Final report, Northwestern University, NSF Grant No. PRA-768-0388, 1978.

RESEARCH AND PLANNING INSTITUTE. Case Studies Examining the Role of Government R&D Contract Funding in the Early History of High Technology Companies. Final report, Small Business Administration Contract No. SBA-2633-OA-79, July 1980.

REID, Samuel Richardson. Mergers, Managers, and the Economy. New York: McGraw-Hill, 1968.

ROGERS, E. "Re-Invention During the Innovation Process." In The Diffusion of Innovations: An Assessment, edited by M. Radnor, I. Feller, and E. Rogers. Final report, Northwestern University, NSF Grant No. PRA-7680388, 1978.

ROGERS, E. M., and F. F. Shoemaker. Communication of Innovations: A Cross-Cultural Approach. New York: Free Press, 1971.

ROTHWELL, R., and W. Zegueld. "Small and Medium Sized Manufacturing Firms: Their Role and Problems in Innovation Government Policy in Europe, the U.S.A., Canada, Japan, and Israel." Vol. 1. Report for the Six Countries Program on Government Policies Toward Technology Innovation in Industry, June 1978.

RUBENSTEIN, Albert H. "Results of Investigation of Specific Cases of Impact of Federal Action on Technology Invention and Innovation." Report for National Bureau of Standards T.A.D. Contract No. S-313569-73, July 1973.

-----, Eliezer Giesler, and Charles W. N. Thompson. "A Method of Assessing the Technical and Innovative Capabilities

APPENDIX III

APPENDIX III

APPENDIX III

of Small Business." Study supported by International Applied Science and Technology Associates, NSF Purchase Order No. 77-SP-0999, 1978.

----- and Robert D. O'Keefe. "Final Technical Report on Field Studies of the Technological Innovation Process." Report for Office of National R&D Assessment, NSF Grant No. DA-39470, September 15, 1974.

----- et al. "A Preliminary Study of Indicators for Small Business R&D Capabilities." Report for National Science Foundation, Office of Small Business Research and Development, 1977.

SCHERER, F. M. Industrial Market Structure and Economic Performance, 2nd ed. Chicago: Rand McNally, 1980.

SCHERER, William K. Small Firms and Federal Research and Development. Washington, D.C.: Office of Management and Budget, 1977.

SCHMOOKLER, J. Invention and Economic Growth. Cambridge: Harvard University Press, 1966.

SCHON, Donald A. Technology and Change. New York: Delacorte Press, 1967.

SCHUMACHER, E. F. Small Is Beautiful. New York: Harper & Row, 1973.

SCHUMPETER, J. Capitalism, Socialism, and Democracy. New York: Harper & Row, 1942.

"Science and Technology in the New Socio-Economic Context." Paris: Organization for Economic Cooperation and Development, September 11, 1979.

SCIENCE POLICY RESEARCH UNIT. Success and Failure in Industrial Innovation. London: Center for the Study of Industrial Innovation, 1972.

SHAPERO, Albert. "Some Social Dimensions of Entrepreneurship." In The Mini-Encyclopedia of Entrepreneurship, edited by D. Sexton et al. Englewood Cliffs, N.J.: Prentice-Hall, forthcoming.

SMALL BUSINESS ADMINISTRATION. The Study of Small Business. Washington, D.C.: U.S. Government Printing Office, 1977.

Small Business and Innovation: A Report of an SBA Office of Advocacy Task Force. Washington, D.C.: U.S. Small Business Administration, 1979.

TAYLOR, James A. "Measuring the Diffusion Process in Educational Systems." Paper for 1975 Conference on Educational Diffusion, Detroit, Michigan.

APPENDIX III

APPENDIX III

TAYLOR, James A., et al. "An Essay on Technology Transfer in Post-Industrial Economies." Paper submitted to the 1979 Annual Meeting of the International Communication Association, Philadelphia, 1979.

TAYLOR, James A. and G. Shive. "A Multidimensional Examination of Political Attitude Change." Paper presented at the 1975 International Communication Association Annual Meeting, Chicago, Illinois.

U.S. Congress, House. Small, High Technology Firms and Innovation. Report Prepared by Subcommittee on Investigations and Oversight of the Committee on Science and Technology. 96th Cong., 2nd sess., 1980.

----- Productivity and the U.S. Economy. Hearings Before the Subcommittee on General Oversight and Minority Enterprise of the Committee on Small Business. 96th Cong., 1st sess., 1979.

----- Small Business and Innovation. Joint Hearings Before the Senate Select Committee on Small Business and the House Subcommittees on Antitrust, Consumers, and Employment and Energy, Environment, Safety, and Research. 95th Cong., 2nd sess., 1978.

U.S. Congress, Senate. Innovation--Startup, Growth, and Survival of Small, New Technology Firms. Joint Hearings Before the House Committees on Science and Technology and Small Business and the Senate Select Committee on Small Business. 96th Cong., 1st sess., 1979.

----- National Strategy for Technological Innovation. Prepared at the Request of Honorable Howard W. Cannon, Chairman, the Committee on Commerce, Science, and Transportation, 96th Cong., 1st sess., 1979.

----- National Technology Innovation Act. Hearings Before the Subcommittee on Science, Technology, and Transportation on S. 1250. 96th Cong., 1st sess., 1979.

----- Small Business and Innovation. Report of the Senate Select Committee on Small Business on Underutilization of Small Business in the Nation's Efforts to Encourage Industrial Innovation. 96th Cong., 1st sess., 1979.

U.S. DEPARTMENT OF COMMERCE, Advisory Committee on Industrial Innovation. Final Report. Washington, D.C.: U.S. Government Printing Office, 1979.

UTTERBACK, James. "The Process of Technological Innovation Within the Firm." Academy of Management Journal, 14 (1971), 76-88.

APPENDIX III

APPENDIX III

ZALTMAN, G., R. Duncan, and J. Holbek. Innovations and Organizations. New York: John Wiley & Sons, 1973.

PROGRAMS THAT PROVIDE FUNDING
FOR THE INNOVATION PROCESS

SMALL BUSINESS INNOVATION
RESEARCH PROGRAM (SBIR)

Goals and objectives

The goal of the SBIR program is to increase the probability of payoff to the public from Federally funded research. The objectives are to

- use small science and technology firms to a greater degree in Federal R&D by supporting high-quality applied research proposals for solving important scientific or technical problems or opportunities that could have significant benefit and
- convert Federal research into technological innovation and commercial application for national socioeconomic benefit.

Funding and operation

The SBIR program was created in 1977 and became a line item in the 1981 National Science Foundation budget. In fiscal year 1981 the program had a budget of \$5 million, the same as it will have in fiscal year 1982. This program solicits high-risk research proposals with a potentially high payoff from small creative science and technology firms.

SBIR serves as a source of early funding in three phases. Phase I is for feasibility studies for experimental or theoretical research efforts on proposed innovative ideas or approaches. NSF provided funds up to \$25,000 for phase I through 1980. This was increased to \$30,000 in 1981. To be funded, the study must concentrate on research that will contribute significantly to proving the feasibility of the approach or concept. By limiting the number of pages in a formal proposal to 20, phase I is also designed to reduce the investment of time and money small firms must make in proposal preparation.

Phase II funding is for the principal research effort. Eligibility to submit a phase II proposal depends on successful completion of phase I. Phase II requires that a comprehensive, standardized proposal be submitted no later than 60 days following the expiration of the phase I award. The program also encourages applicants to secure a commitment for private follow-on funding at least equivalent to the amount of research funds requested from NSF for phase II. This commitment must be from a private source to develop and commercially apply research supported by NSF under phases I and II. Under phase II, NSF provides up to 24 months of support for up to three professionals annually, depending on the scope of the research.

APPENDIX IV

Phase III, conducted by the small business, is privately funded by the third party that makes the follow-on funding commitment. The purpose of phase III is to pursue the commercial objectives that arise from the NSF research conducted in phases I and II.

LOCATION: Directorate for Scientific, Technological,
and International Affairs
National Science Foundation
1800 G Street N.W.
Washington, D.C. 20550

APPROPRIATE TECHNOLOGY SMALL GRANTS PROGRAM (AT)

Goals and objectives

The Appropriate Technology Small Grants program was established in 1977 to enable inventors, innovators, small businesses, and local nonprofit groups to apply their skills to developing small-scale technologies that supplement, complement, or provide alternatives to large-scale technologies. The following program objectives were developed to meet this goal:

- to provide individuals and groups with access to the Department of Energy that they would not otherwise have,
- to make technology available that would not otherwise be accessible to DOE,
- to further national efforts to promote the use of renewable resources and conserve nonrenewable resources, and
- to make more energy-related technology options available in the United States.

Funding and operation

The AT program was funded in fiscal year 1980 for \$12 million, and a similar amount was requested for fiscal year 1981.

The AT program provides grants for developing small-scale, energy-related technologies that are "appropriate" to local needs and skills. Funds are provided for a wide variety of projects in one of three categories:

1. Awards of up to \$10,000 are made for the development of an idea, concept, or investigative finding in areas ranging from new concepts of energy resources to the new application of existing procedures or systems.
2. Awards of up to \$50,000 are made for the development of a concept into a useful technology. This category includes design, assembly, and laboratory tests to determine the concept's technological feasibility and application.
3. Awards of up to \$50,000 are made to test or demonstrate a technology under operating conditions to show that its commercial use is feasible.

APPENDIX IV

APPENDIX IV

LOCATION: U.S. Department of Energy
Office of Inventions and Small Scale Technology
1000 Independence Avenue S.W.
Washington, D.C. 20585

ENERGY-RELATED INVENTIONS PROGRAM

Goals and objectives

The Energy-Related Inventions Program was created to provide the individual inventor or small-business person with financial and technical assistance for developing and marketing an energy-related idea. This goal is met by providing support directly to the inventor or business person. The program's objectives are to

- evaluate inventions,
- provide technical and financial support, and
- assist in the early stages of the commercialization of inventions that will contribute significantly to energy conservation.

Funding and operation

The program was funded in fiscal year 1980 for \$4.2 million, in fiscal year 1981 for \$5.4 million, and in fiscal year 1982 for \$5.4 million. It performs the role of financial backer and advisor to inventors or small businesses. The program offers one-time assistance, usually amounting to 1 year of financial and technical support. Assistance is negotiated directly with the inventor or small-business person.

An inventor enters an idea for consideration by submitting an evaluation request form to the National Bureau of Standards. Examiners there ask three key questions in their evaluation of the application:

- Is the invention technically competent and unique?
- Will the invention save a significant amount of energy?
- Does the invention have a reasonable chance of becoming a commercial success, given the appropriate Federal assistance?

If the National Bureau of Standards renders a favorable evaluation of an inventor's idea, the Department of Energy considers making a grant. If DOE decides to assist the inventor, support may be given in the form of a grant or a contract or direct assistance to a business of a technical nature.

LOCATION: U.S. Department of Energy
Office of Inventions and Small Scale Technology
1000 Independence Avenue S.W.
Washington, D.C. 20585

SMALL BUSINESS ADVANCED
TECHNOLOGY PROGRAMGoals and objectives

The goal of this program is to capitalize on the historically creative potential of small, high-technology firms. The program has one objective--to promote innovative solutions to scientific and technical problems facing the national defense community by increasing the participation of small, high-technology firms in the research and development initiatives of the Department of Defense.

Funding and operation

The program, initiated in April 1981, will identify for exploration 20 research and development projects of particular interest to the Army, Navy, Air Force, and Defense Advanced Research Projects Agency (DARPA), under a three-phase program. Proposals are to be submitted to the respective services and to DARPA by August 31, 1981, and the program expects to fund \$5 million to \$8 million in research and development in fiscal year 1982.

Phase I awards of up to \$50,000 are contemplated for preliminary research and development to demonstrate the feasibility of ideas deemed most likely to provide solutions to R&D problems identified by the military departments and DARPA. This phase will last for 6 months. A key feature of the program is that the paperwork burden on small firms has been drastically reduced and the initial investment in proposal writing has been reduced by limiting proposals to 20 pages.

Phase II awards ranging from \$100,000 to \$500,000 for advanced development contracts will be based on the results of phase I efforts. Projects judged most promising will be funded for up to 2 years.

Phase III will include follow-on DOD production awards and commercial application of the R&D, if appropriate. Commercial application must be funded with private capital.

LOCATION: U.S. Department of Defense
Director for Small Business and Economic
Utilization Policy
Office of the Under Secretary of Defense for
Research and Engineering (Acquisition Policy)
Room 2A340
The Pentagon
Washington, D.C. 20301

PROGRAMS THAT PROVIDE TECHNICAL
AND MANAGEMENT ASSISTANCE

TECHNOLOGY COMMERCIALIZATION PROGRAM

Goals and objectives

This program was developed to assist minority firms at the earliest stage practicable in entering and competing in the rapidly growing industries that are technologically based. The program provides this assistance by funding eight Technology Commercialization Centers throughout the United States. The objectives of the Centers are to

- provide the sophisticated level of services required for technology-based business opportunities for minority firms,
- define and attack problems that inhibit technological growth in minority enterprise, and
- coordinate government and industrial resources--that is, create a partnership between public and private sectors in support of minority enterprise.

Funding and operation

The Technology Commercialization program was funded in fiscal year 1980 for \$1.1 million. Funding for fiscal year 1981 is \$1.891 million. Anticipated funding for fiscal year 1982 is \$1.9 million.

This program brokers for qualified minority firms developing new products and services. It helps coordinate (1) the access to and matching of information about available technologies with commercial potential with (2) market potentials for new products and (3) financial sources for new product development.

One of the program's principal functions is to provide direct services where possible, such as evaluations of a new product's technical soundness and market potential. This facilitates a match with potential sources of financing. These services are provided by the following Centers:

Booker T. Washington Foundation
2000 K Street N.W.
Washington, D.C. 20006

Booker T. Washington Foundation
36 South Charles Street
Baltimore, Maryland 20201

Center for Arid & Tropical New Crop Applied Science
& Technology (NEWCAST)
Agriculture Science Building, Room 221
Arizona State University
Tempe, Arizona 85281

APPENDIX V

APPENDIX V

Department of Community Development
Technology Commercialization Center
City of Long Beach
333 West Ocean Boulevard
Long Beach, California 90802

Industrial Technology Research and Development
Foundation, Inc.
P.O. Box 1335
Durant, Oklahoma 74701

Middle Atlantic Technology Commercialization Center
Caswell Building, Suite 219
Koger Executive Center
Raleigh, North Carolina 27612

New England Technology Commercialization Center
15 Lewis Street
Hartford, Connecticut 06103

Northwest Technology Center
1370 Stewart Street
Seattle, Washington 98109

Technology Utilization and Commercialization Center
Engineering Experiment Station
Georgia Institute of Technology
Atlantic Steel Building
Atlanta, Georgia 30332

LOCATION: U.S. Department of Commerce
Industry and Technology Division
Office of Enterprise Development
Minority Business Development Agency
Washington, D.C. 20230

SMALL BUSINESS ADMINISTRATION
INNOVATION CENTERS EXPERIMENT

Goals and objectives

This is a small experimental program designed to bring new and improved high-technology applications and innovations to the marketplace to improve U.S. employment and productivity.

Funding and operation

The program had a fiscal year 1980 budget of \$730,000, with no budget projected for 1981.

Three organizations were funded to provide technical and management assistance to small innovative businesses. The three are the Golden Gate Energy Center (San Francisco, California),

APPENDIX V

APPENDIX V

the Montana Energy Research and Development Institute (Butte, Montana), and the Commercial Credit Services Corporation, a subsidiary of Control Data Corporation (Baltimore, Maryland). We discuss the operation of these three innovation centers in the remainder of this appendix.

LOCATION: Small Business Administration
Office of Policy Analysis
1441 L Street N.W.
Washington, D.C. 20416

GOLDEN GATE ENERGY CENTER

Goals and objectives

The Golden Gate Energy Center's program was designed to provide technical and financial assistance to innovative small businesses entering the fields of energy conservation and renewable energy resources.

Funding and operation

For fiscal year 1981, the Center was awarded a 1-year Small Business Administration contract of \$250,880 to support its activities. The Center provides counseling assistance on

- marketing research and planning,
- accounting and business procedures,
- development of financial statements (profit and loss, balance sheets, cash flow projections, and so on),
- financial and venture capital planning,
- source analysis of investment capital for various types of energy conservation innovations (solar, wind, geothermal),
- planning for production, purchasing, personnel, future R&D, sales and service, and
- referrals to appropriate Federal, State, and private institutions.

These activities contribute to the development of plans that can assess the extent of risk and reward that a business can expect. The purpose of a business and financial plan is to set realistic goals and objectives that the founders of a business can actually expect to accomplish.

The Golden Gate Energy Center program uses the expertise of other individuals within Government agencies for support services.

APPENDIX V

At the Federal level, the Center assists SBA and DOE in inter-agency coordination of the project. The Center also works with SBA in selecting certain target businesses as client projects for business assistance.

LOCATION: Building 1055, Fort Cronhite
Sausalito, California 94965

MONTANA ENERGY AND MHD RESEARCH
AND DEVELOPMENT INSTITUTE (MERDI),
CENTER FOR INNOVATION (CFI)

Goals and objectives

MERDI listed the following objectives for the first-year agreement with SBA:

- to continue assessing the effectiveness of MERDI/CFI programs in assisting in the invention and commercialization of new products and processes and
- to identify potential regions for Centers in the United States, recommend most likely regions, and on only a limited scale demonstrate the need, interest, and regional response to a CFI-type program.

Funding and operation

MERDI was awarded a 1-year SBA contract for fiscal year 1980 for \$250,000 to support innovation Center activities. MERDI's first objective is to support partially the continued operation of the first regional CFI supported by SBA in the Old West Regional Commission States. MERDI also proposes to duplicate this concept and operation at other locations across the United States.

The second objective is to ask the possible new regional locations to propose and set up Centers on their own behalf. The services of the CFIs will include but not be limited to

- evaluating ideas for technical, manufacturing, and marketing feasibility,
- giving assistance in the fabrication of prototypes,
- constructing financial packages for innovations,
- preparing brochures and manuals, and
- marketing the products.

LOCATION: P.O. Box 3809
Butte, Montana 59701

COMMERCIAL CREDIT SERVICES
CORPORATION (CCSC)

Goals and objectives

The Commercial Credit Services Corporation is an operating company of Commercial Credit Company, the wholly owned financial services subsidiary of Control Data Corporation. CCSC has designed a program to assist individuals and small businesses in developing innovations and new technologies. The program objectives are to

- bring new or improved technology and innovation to the marketplace and
- improve employment and productivity in the United States.

Funding and operation

SBA awarded CCSC a 9-month contract from October 1980 through June 1981 for \$223,770.

CCSC provides the following services to clients:

- evaluation of ideas' technical feasibility,
- identification of practical applications,
- evaluation of markets,
- determination of types of resources required to develop and market innovations,
- evaluation of the clients' business plans or, if no plan exists, work with clients to develop business plans,
- assistance in locating resources required to implement business plans.

LOCATION: Technology and Innovation Development Program
Commercial Credit BSP12D
300 St. Paul Place
Baltimore, Maryland 21202

APPENDIX VI

APPENDIX VI

NATIONAL SCIENCE FOUNDATION
WASHINGTON D C 20550

nsf

OFFICE OF THE
DIRECTOR

May 28, 1981

Mr. Morton A. Myers
Director, Program Analysis Division
Room 5033
U.S. General Accounting Office
Washington, D.C. 20548

Dear Mr. Myers:

- 1 This is in response to your request for NSF comments on the draft GAO report entitled "Small Businesses and Innovation: An Approach to Assessing Federal Initiatives."
- 2 We believe the GAO draft study is an interesting presentation on the contribution of small businesses to the process of innovation in the private sector. The draft subject report describes the NSF Small Business Innovation Research program accurately with minor editorial changes as suggested below. Besides these editorial comments, we have one general comment on the draft.
- 3 As a general comment, we feel the report should more completely reflect the importance of the entrepreneurial role in the initiation and development of new small businesses. The report should also recognize more the importance of the key individual or individuals in implementing the various components of the innovation process from idea generation to later stage financing of growing businesses. The report implies that the resources and stimulation necessary for business development are essentially mechanical or structural in form with no personal attributes or profit motive identified with the innovation process. This leaves one with the impression that when such structural components are available, business development will naturally follow. Experience has shown that this may be the exception rather than the rule.
- 4 In addition, we have the following editorial comments:
 - (1) The SBIR program "encourages" rather than requires a follow-on funding commitment. See third line from the bottom on page 57 and line 9 on page iv-2.

APPENDIX VI

APPENDIX VI

Mr. Morton A. Myers

2.

5 (2) See second paragraph page iv-1, first sentence. The SBIR program began in 1977 and became a line item in the NSF budget in Fiscal year 1981. On the third line from the bottom of the page, NSF provided funds up to \$25,000 for phase I through 1980. This amount was increased to \$30,000 in 1981.

6 (3) In that the report will have a 1981 date and includes reference to the very recent Department of Defense program, the topics shown in the footnote on page 55 for the 1980 solicitation might be changed to reflect the 1981 solicitation. The latter topics were chosen, in part, because they had more innovation potential.

7 (4) End of first paragraph, page 57. Funding for phase II may be provided even if the small firm does not meet all phase I objectives. Phase II awards are based upon a review of the results of phase I and of the phase II proposal. In general, the project must be highly promising after the completion of phase I.

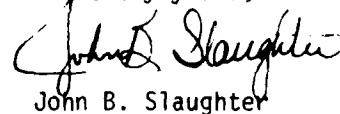
8 (5) The SBIR program does involve the evaluation of management, the potential market, and future financing requirements by requiring that any follow-on funding commitment for phase III be obtained from a third party in the private sector. However, NSF support solely funds research. The program approach is that it is more objective and more appropriate for the private sector to evaluate these factors, but government provides the incentives for these factors important to the innovation process to take place.

9 (6) The Senate Small Business Committee is no longer a "Select" committee. See page 3, seventh line from the bottom.

10 (7) In the footnote on page 69, the "Dear Colleague" letter was sent in 1980 by the Industry/University Cooperative Research Projects program prior to the formation of the Division of Industrial Science and Technological Innovation (ISTI) in March 1981. The program is now a part of ISTI.

11 I understand members of the NSF staff have met informally with GAO representatives to discuss the draft report. We would be happy to discuss these matters further with GAO.

Sincerely yours,


John B. Slaughter
Director

GAO RESPONSE TO NSF COMMENTS

The numbers of the responses below correspond to the numbered paragraphs of the May 28, 1981, letter from John B. Slaughter, Director of the National Science Foundation.

1. No response is required.

2. No response is required.

3. Our response is given in chapter 5.

4-7. The changes that are indicated have been made.

8. NSF is amplifying a point made in the report. No response is required

9-10. The changes that are indicated have been made.

11. No response is required.

APPENDIX VII

APPENDIX VII



U.S. SMALL BUSINESS ADMINISTRATION
WASHINGTON, D.C. 20416

JUN 4 - 1981

Mr. Henry Eschwege
Director
Community and Economic Development
Division
United States General Accounting Office
Washington, D. C. 20548

Dear Mr. Eschwege:

- 1 This is in response to your letter of April 29, 1981, requesting our comments on your proposed report entitled, "Small Businesses and Innovation: An Approach to Assessing Federal Initiatives."
- 2 We believe the report is an excellent analysis of the Federal initiatives as they impact on the innovation efforts of small businesses. It sets forth rather specific criteria against which the Federal initiatives to support small business innovation efforts may be judged. However, the study does not give adequate emphasis to the extent to which the profit motive creates the incentive for the innovative effort, whether it be in large or small businesses. It may well be that this rather obvious criterion was felt to be addressed by the reference on page 25, paragraph 2, which states that "implicit in the availability of capital and resources is the concept of profitability. Innovative projects will not be undertaken if they are not expected to yield the return of investment required by the firms initiating the projects. Invention is least likely to be constrained by profitability considerations, but the development in commercialization of innovations are certainly tied to the promise of future profits." We feel it would be fair to challenge the comment that "inventions are least likely to be constrained by profitability considerations." Throughout history it seems that the profit motive has been primary in people who consider the need for a new product. In other words, the question most likely to be asked is how much fame or fortune will be mine if, in fact, I develop this item whether it is a new product or a new process.
- 3 It would not be necessary in this particular study to include a full scale review of the capitalistic system particularly as it impacts on the innovation efforts of the small business community. However, it would seem very appropriate that this consideration be kept foremost in mind and wherever possible throughout the study to

APPENDIX VII

APPENDIX VII

Mr. Henry Eschwege

Page 2

include a reference to the profit motive as being fundamental to the strengths of America's economy. Our entire system is built on the basis of a profit in return for an investment of time, effort or money. In fact, very little in our economy will move without a profit.

- 4 It seems that any legislative activity or any administrative mandate should be addressed to this specific point. The question could well be asked, how will this particular regulation, rule or mandate affect the profit of the individual or firm to the extent that it will enhance the ability to make a profit, or contrariwise to the extent that it will detract from the person's ability to make a profit. This should be a prime consideration. If it will enhance profitability, it obviously could be considered as aiding in the innovative process. If it would detract from profitability, it could well be perceived as something which would hinder the innovative process. Perhaps, at the outset of this analysis, a short statement could be included simply summing up this particular factor.
- 5 One other comment would seem appropriate at this time and that is that in this study references are made to the small business innovative centers. It must be emphasized this is an experimental project where limited funding has been made available to three centers throughout the country. The objective is to see if, in fact, each kind of center approach does substantially increase creative innovation. It is rather premature to comment because the evaluation of these centers and their effectiveness has not as yet been made. However, the evaluation is imminent and results of such an evaluation should be ready by the latter part of June.
- 6 Therefore, it would be well to delete any references to the SBA innovation centers from the study until an evaluation has been made at which time comments could be included either on a positive or negative basis.
- 7 We appreciated the opportunity to comment on this report and if we can be of further assistance, please advise.

Sincerely,



Michael Cardenas
Administrator

APPENDIX VII

APPENDIX VII

GAO RESPONSE TO SBA COMMENTS

No response is required for paragraphs 1 and 7 of the June 4, 1981, letter from Michael Cardenas, Administrator of the Small Business Administration. Our response to paragraphs 2 through 6 is given in chapter 5.

APPENDIX VIII

APPENDIX VIII



UNITED STATES DEPARTMENT OF COMMERCE
Office of Inspector General
Washington, D.C. 20230

JUN 3 1981

Mr. Henry Eschwege
Director, Community and Economic
Development Division
U. S. General Accounting Office
Washington, D. C. 20548

Dear Mr. Eschwege:

This is in reply to your letter of April 29, 1981, requesting comments on the draft report entitled "Small Businesses and Innovation: An Approach To Assessing Federal Initiatives."

We have reviewed the enclosed comments of the Acting Assistant Secretary for Productivity, Technology and Innovation for the Department of Commerce and believe they are responsive to the matters discussed in the report.

Sincerely,

Frederic A. Heim, Jr.
Frederic A. Heim, Jr.
Assistant Inspector General
for Auditing

Enclosure

APPENDIX VIII

APPENDIX VIII



UNITED STATES DEPARTMENT OF COMMERCE
The Assistant Secretary for Productivity,
Technology and Innovation
Washington, D.C. 20230
(202) 377-3111

June 3, 1981

Mr. Henry Eschwege
Director, Community and
Economic Development Division
U.S. General Accounting Office
Washington, D.C. 20548

Dear Mr. Eschwege:

- 1 I would like to thank you very much for the opportunity to review and comment upon the draft report to Congress entitled "Small Businesses and Innovation: An Approach to Assessing Federal Initiatives." This report, forwarded to the Secretary of Commerce, has been referred to my office for comment and reply. The following comments include not only those that have been developed by my own office, but also those which have been provided to us by the Minority Business Development Agency (MBDA). This latter agency has a strong interest in small business development, is referred to explicitly in the report, and has contributed to the development of new businesses based upon technological innovations.
- 2 The subject addressed by this report is one which is of considerable importance. We congratulate GAO for attacking this subject matter. The approach taken is systematic, unbiased, and more comprehensive than existing studies. It avoids making smallness a virtue by itself. As the authors point out in the text, other studies which have frequently been cited by advocates of small business, contained serious methodological problems which make their utilization for policy analysis and decisions difficult. This report attempts to set up a framework for this purpose and, in this context, should prove very useful and valuable. It is a framework which, with some possible exceptions concerning nomenclature, is consistent with one which has been utilized by MBDA in its successful operations over the course of more than four years.
- 3 The MBDA experience supports the analytical framework presented in the report. The proper matching of circumstances, people and resources provides the environment that is conducive for innovation. The MBDA Technology Commercialization Program (TCP) incorporates the following MOST IMPORTANT criteria: (1) encouragement of exploitation of technological opportunity; (2) mechanisms to insure that participating firms have managerial and technical capability for support at each stage of the commercialization process; (3) mechanisms to insure that financial and human resources are adequate and available; and (4) selection of

APPENDIX VIII

APPENDIX VIII

-2-

technologies and/or industries in which small business can be expected to acquire the necessary resources to support each stage of the innovation process. In addition, the TCP appears to meet the following two IMPORTANT criteria: (1) "stimulate creation and augmentation of technological opportunity"; (2) "increase availability of financial and human resources." The TCP operation, building and brokering a national pool of resources, has identified and matched sources of technology, adaptive engineering, financing and producers of products and services. Access to technological opportunity and resources, specifically cited by the report, has been critical to the process of innovation. Private sector, university, and Federal Government resources have been successfully coordinated to establish an innovation network in most areas of technological innovation. The Federal laboratories have contributed strongly to this process.

- 4 The report might note a recently completed "Evaluation of the Technology Commercialization Program," by M.L. Grad Consultants, May 1981. This report provides additional data and conclusions which support the framework of the GAO report. Based upon this evaluation, MBDA is developing a 5-7 year plan for TCP. Ongoing reviews could provide input and operating experiences over a period of time appropriate to the innovation process.
- 5 The TCP experience has demonstrated that public and private sectors can work together in the innovation process. Large and small businesses can also work together, provided that both perceive potential profit. The TCP operating experience, incorporating a flexible response to the needs of the small innovative firms and involving coordination, support, and leveraging of existing resources, validate the environmental and programmatic criteria cited in the GAO report.
- 6 The report in its current form does, however, present some problems. Let me first address these problems in a general way before making specific comments.
- 7 It is our opinion that the report requires considerable editing and tightening-up in order for it to become as useful and valuable as we believe that it is. The introductory Digest is overly long and rambling. It is difficult to follow the message, conveyed by the report in its entirety, by reading the Digest alone. The introductory chapter is comparatively brief and adequate to introduce the concepts that are to be developed further in the report. Within this chapter are discussed the environment for innovation, the various climates for different levels, and the interactions and interrelationships as they influence innovation. The attempts to "model" these very complex concepts, as discussed in Chapter 2, raise more questions than they help to answer. Chapter 2 appears to be diverting attention from the main issues at hand, is a digression from the flow of the report, and could perhaps be condensed together with Chapter 1 in a simplified presentation. An alternative approach to illuminate these complex interactions more vividly might be the inclusion of case studies as examples of the interactions which are being discussed.

- 3 -

8 Some specific comments follow:

- o In-depth case studies might provide more limited, but nevertheless more practical, conclusions. Industries exist that contain significant market segments with different product preferences. Small firms making special purpose sensors compete very well in an industry dominated by Honeywell, Foxboro, etc. Frequent changes in population of firms, such as in the fashion or publishing industries, may be indicative of uncertainty or rapid style changes. In a high technology industry, such as semi-conductors, this may signify intense competition and rapid technological innovation.
- 9 o The report is principally concerned with technological innovation. Yet occasional reference is made to management and service innovation, without significant elaboration. At times they are tied into product and process innovation. It is suggested that the focus of this report should be identified as product and process innovation solely.
- 10 o Large businesses have tended to concentrate on incremental innovations, particularly in recent years. Small businesses on the other hand are more attuned to major or radical innovations. This distinction is not clearly made in the report.
- 11 o Many radical innovations come from outside a particular industry. This fact is not explicitly recognized in the report.
- 12 o Figure 7 apparently equates increasing capital intensity to industry structure. Farming has an atomistic industry structure but uses very capital intensive technology. The life-cycle of an industry may also be relevant to this discussion.
- 13 o The discussion on pages 47-48 with regard to R&D tax deduction incentives is incomplete. Many technological small businesses do conduct R&D programs but will not benefit from a tax deduction because they lack the profits against which this deduction might be offset. On the other hand, a refundable tax credit might offset this problem.
- 14 o On page 48, in the paragraph concerning industry climate, the report states that the balance of entry barriers and incentives is not very responsive to Federal policy and changes. This overlooks possible policy changes in the financial and venture capital area, such as modifications of SEC regulations concerning small stock issues, clarification of ERISA regulations, SBIC formations, etc.

APPENDIX VIII

APPENDIX VIII

-4-

15 o The report identifies technological opportunity as a very important component in the innovation process. The relationship between creation and exploitation of technological opportunity could be expounded in terms of technology transfer. This area is addressed by Section 11 of P.L. 96-480. However, this law is not listed in Table 6 on page 52 nor in any other place in the report. Although implementation of this Act remains in question, it is our understanding that numerous Federal laboratories intend to set up the offices required by Section 11. The MBDA experience also supports the importance of technology transfer activities from the Federal laboratories.

16 o The discussion of the role that patents can play in small business innovation could be strengthened.

17 o Small business trade policy issues are not discussed. Their potential contribution to the balance of trade have been the subject of several legislative initiatives.

18 o The following corrections should be made to the TCP description given in Appendix V, page V-1:
Line five should read: "8 Technology Commercializations Centers" not "9".
Lines seven - nine should be changed to read: "provide the sophisticated level of services required for technology-based business opportunities for minority firms".
Line 23 should read: "with (2) market potentials for new products" rather than with market searches for new products".

19 In summary, we believe this report to be an extremely important report and that the concepts presented in this report have considerable validity, particularly in view of the MBDA operational experience. However, we believe that rather extensive modifications of the text are desirable to increase the potential readership and, hence, the influence of the report. Case studies may enhance the readability of the report, as well as the interest and understanding of the reader. We urge that these suggestions be considered carefully so that the report, which deals with an extremely important subject area, can have as extensive a readership as is possible.

Sincerely,


Robert B. Elert
Acting Assistant Secretary for
Productivity, Technology and Innovation

GAO RESPONSE TO DOC COMMENTS

The numbers of the responses below correspond to the numbered paragraphs of the June 3, 1981, letter from Robert B. Ellert, Acting Assistant Secretary for Productivity, Technology, and Innovation of the Department of Commerce.

1. No response is required.
2. Our response is given in chapter 5.
3. DOC is confirming what is in the report given DOC's experience with the MBDA Technology Commercialization Program, and no GAO response is required. Line 5 of the paragraph refers to "MOST IMPORTANT criteria"; this term was replaced in the final report with the term "necessary criteria."
4. The Grad report is restricted and not yet a public document; we have not yet been able to obtain a copy of it. Therefore, a response is not appropriate.
5. Our response is given in chapter 5.
6. No response is required.
7. Our response on the question of models is given in chapter 5.
8. We addressed the question of case studies in our response to paragraph 7 in chapter 5. We agree with DOC's comment regarding the different functions of small firms given different market segments of specific industries. In chapter 3, we have discussed in detail how the activities of small businesses vary from industry to industry.
9. We have modified the methodology section of the report (in chapter 1) to clarify that we are concerned with product and process innovations, not management or service innovations.
10. It was not our purpose in this report to determine what kind of innovation--whether "incremental" or "radical"--is made by large or small businesses. We have no empirical evidence to support or dispute this statement by DOC.
11. It was not our purpose to examine whether radical innovations come from outside a particular industry. We have no empirical evidence to support or dispute this statement by DOC.
12. Figure 7 is a characterization used to illustrate that the activities of small businesses in innovation change as the industry structure changes. Industry structure is determined by a number of factors, one of which is capital intensity. In

AD-A101 706 GENERAL ACCOUNTING OFFICE WASHINGTON DC PROGRAM ANAL--ETC F/6 5/1
CONSISTENT CRITERIA ARE NEEDED TO ASSESS SMALL-BUSINESS INNOVAT--ETC(U)
JUL 81

UNCLASSIFIED GAO/PAD-77-71

NL

2 OF 2

AD A
0101001



END
DATE
FILED
8-81
DTIC

APPENDIX VIII

APPENDIX VIII

response to this comment, we have qualified the description of figure 7 in the text on page 26.

13. The text on the draft's page 48 has been changed to incorporate the notion of necessity of profits before tax deduction benefits accrue (see p. 32).

14. We have responded to this comment by eliminating the word "much" from the sentence DOC refers to. The sentence now reads "The industry's rate of growth and competition and its balance of entry barriers and entry incentives are less responsive to policy changes . . ." (p. 32). We did not specifically examine the influence of the possible policy changes on entry barriers and entry incentives in industries that DOC cites. We have no evidence to support or dispute DOC's statement.

15. We have not attempted to include an exhaustive list of all Federal activities that might be expected to influence innovation in general or small-business innovation in particular. Because Public Law 96-480 is not primarily concerned with small-business innovation in particular, we did not select it in choosing illustrations for the application of the criteria we developed in this report.

16. We believe that our treatment in this report of the role of patents in small-business innovation is adequate and appropriate.

17. It was not our purpose in this report to discuss trade policy issues relative to small-business innovation.

18. The changes that are indicated have been made.

19. Changes in the text of this report were made as noted in the items above. DOC's request for "extensive modifications of the text" "to increase the potential readership" of the report is based on DOC's opinion that we should discuss topics it has not been our purpose to discuss, as we have indicated in a number of the other items above.

(974173)

